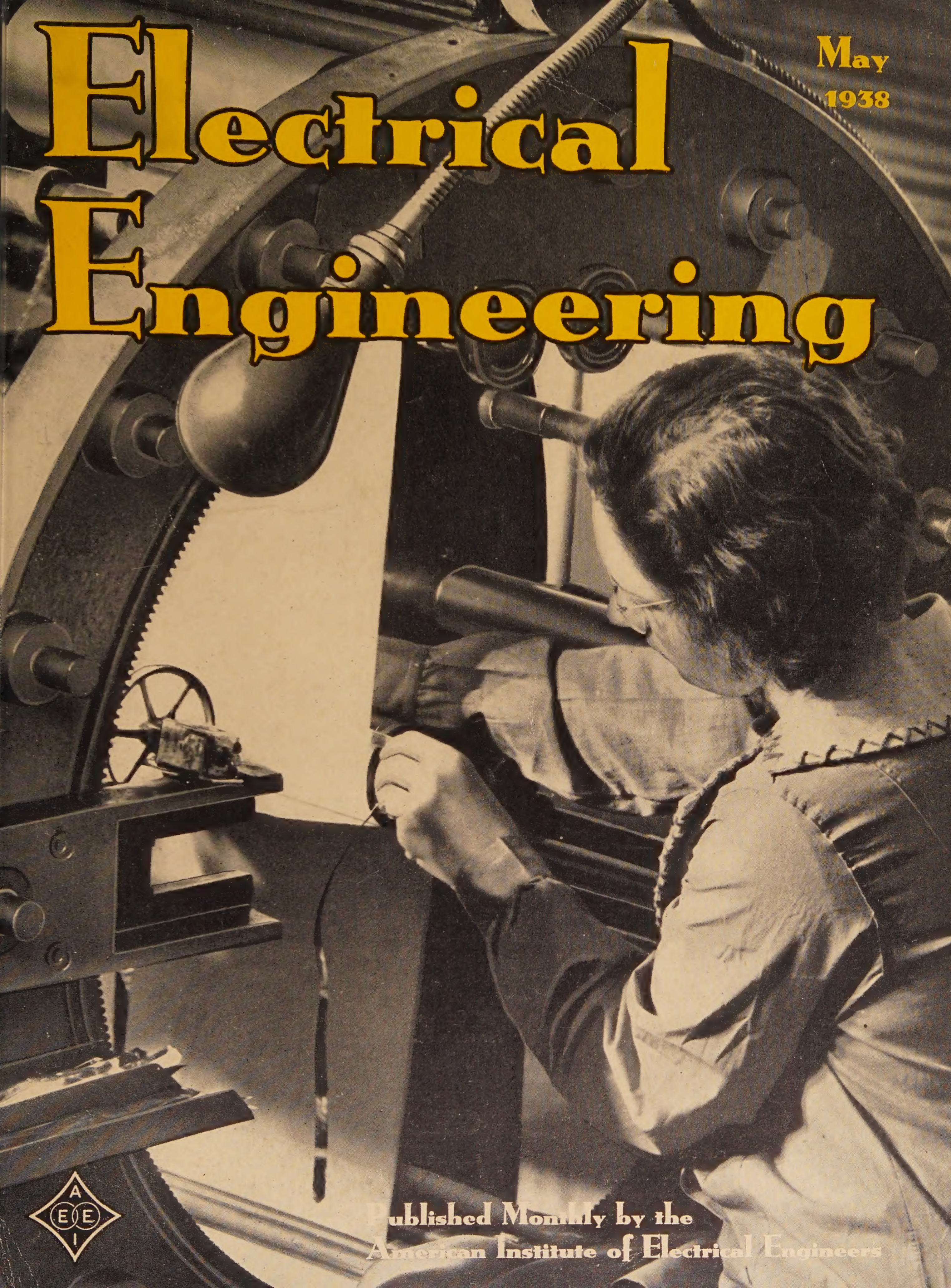
Electrical Engineering

May
1938



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Electrical Engineering

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The Cover

Winding capacitors in the Pittsfield, Mass., works of the General Electric Company. Those attending the AIEE North Eastern District meeting, May 18–20, in nearby Lenox will have an opportunity to visit this plant

High Lights

Carrier System for Toll Cables. Constituting a symposium at the AIEE 1938 winter convention, a group of four papers by nine Bell System engineers described a new carrier telephone system for toll cables; all four papers and related discussions are published in this issue. The new system provides 12 channels on one pair of wires and has repeaters every 17 miles; no loading coils are used in these circuits (*Transactions pages 227–36*). Terminal apparatus for the new system has been designed to form a basic part of the terminals of other carrier systems now under development (*Transactions pages 237–44*). Quartz crystals are used as filter elements in the channel-selecting filters of the system, in order to obtain abrupt discrimination between wanted and unwanted frequencies and at the same time to secure low and uniform loss in the transmitted band (*Transactions pages 245–9*). Small adjustable mutual-inductance coils are connected between carrier pairs to balance out cross-talk; noise is kept at an extremely low level (*Transactions pages 250–61*).

Summer Convention. Members who have planned sometime to visit the Nation's Capital but who have not yet done so are offered an unusual opportunity to combine a sightseeing trip with attendance at the AIEE 1938 summer convention, which will be held in Washington, D.C., June 20–24. The technical program, details of which will be announced later, tentatively comprises ten technical sessions and six conferences. Inspection trips to many government buildings and points of historic interest in and near Washington are being arranged. The program will include also competitions for the Mershon and Lee trophies and other sports events and interesting social activities (*pages 221–4*).

Relays for Differential Protection. Large power transformers, a-c generators, and station bus systems commonly are protected by differential relays. Such relays sometimes are subject to false operation by differential currents not caused by internal faults in the protected equipment. The utilization of the harmonic components of these currents for restraint is said to afford an effective and generally applicable means of preventing false operation (*Transactions pages 262–71*).

Radioactivity. Spontaneous emission of radiant energy is a property possessed naturally by certain elements, as was discovered 40 years ago; more recently artificial means for inducing radioactivity in substances not possessing this property in nature have been found, and now a radioactive form is lacking for only one of all known elements (*pages 193–203*).

Current-Limiting Reactors. Although the use of current-limiting reactors is detrimental to the normal operation of electric systems, such reactors are valuable in contributing to the safety of systems during faults. Many plans to minimize the undesirable characteristics and at the same time retain the desirable protective features have been proposed (*Transactions pages 272–80*).

Lenox Meeting. A very informal stag smoker is one of the events on the program of the North Eastern District meeting to be held in Lenox, Mass., May 18–20, 1938, details of which are included in the final announcement. Speakers for the general session and for the mixed banquet also are announced (*page 224*).

Electronic Switching. Circuits may be made operative or inoperative by a change of polarity or magnitude, or both, by means of electronic devices, as well as by the more common physical opening and closing by circuit breakers and knife switches. One type of electronic switch offers control of a large number of circuits (*pages 209–20*).

Young Engineers. College graduates entering industry face many adjustments from campus life, and failure to meet them may result in dissatisfaction to the employer and disappointing progress for the engineer. A summary of 16 points of advice may guide the new graduate (*pages 206–08*).

Submarine Cables. Maintenance of the world's submarine telegraph cables is performed by ships specially equipped for this service; one such ship now is engaged in experiments to increase the protection of cables by burying them in the ocean bottom (*pages 204–05*).

Pacific Coast Convention. A joint session with the Pacific Coast members of the Institute of Radio Engineers is being planned for the AIEE 1938 Pacific Coast convention to be held in Seattle, Wash., August 9–12 (*page 225*).

Year Book. The AIEE 1938 Year Book has been issued and is available to members who have use for it (*page 225*).

Coming Soon. Among articles and papers now undergoing preparation for publication in early issues, are the following: an article describing a coaxial cable system for television transmission by M. E. Strieby (M'22); an article reviewing electrical precipitation by W. A. Schmidt (M'22) and Evald Anderson; an article on the use of electricity in medicine by R. E. Williams (A'35); a paper describing electron-tube theater-lighting control by E. D. Schneider (A'32); a paper describing a new type of metal-glass-porcelain seal for introducing electrical leads into sealed containers by W. E. Bahls; two papers on the use of electron tubes for the power supply and control of d-c motors by C. C. Clymer and R. G. Lorraine (M'36), and G. W. Garman (A'38), respectively; two papers on modern electric vehicles for urban passenger transportation by Thomas Fitzgerald (A'02) and R. H. Stier, respectively; a paper presenting data on discharge currents in lightning arresters on distribution systems by K. B. McEachron (F'37) and W. A. McMorris (M'37); a paper presenting operating results with a Petersen coil on a 100-kv line traversing mountainous country and exposed to lightning by W. D. Hardaway (M'32) and W. W. Lewis (M'13).

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Characteristics of the New Station-Type Autovalve Lightning Arrester—Roman 286
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A New High-Speed Distance-Type Carrier-Pilot Relay System—Harder, Lenehan, Goldsborough 291

Statements and opinions given in articles and papers appearing in Electrical Engineering are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters. ¶ Subscriptions—$12 per year to United States, Mexico, Cuba, Porto Rico, Hawaii, Philippine Islands, Central and South America, Haiti, Spain, Spanish Colonies; $13 to Canada; $14 elsewhere. Single copy $1.50. ¶ Address changes must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge. ¶ Electrical Engineering is indexed annually by the Institute, weekly and monthly by *Engineering Index*, and monthly by *Industrial Arts Index*; abstracted monthly by *Science Abstracts* (London). ¶ Copyright 1938 by the American Institute of Electrical Engineers. Number of copies this issue—21,700.

Radioactivity, Artificial and Natural

By K. K. DARROW
ASSOCIATE AIEE

In a very few years after its discovery in 1898, radioactivity became and has ever since remained the most celebrated subdivision of modern physics. In addition to substances naturally radioactive, such as radium, others may be made so artificially; in fact, of all the known elements, hydrogen alone remains the only one of which a radioactive type has not been discovered or invented.

RADIOACTIVITY is a world-famous word relating to a world-famous subject. In general, when a statement of this sort is spoken, it is more than likely to be foolish; for specialists are altogether too addicted to imagining that their special interests are of world-wide concern when perhaps not fifty thousand people have ever even heard of them. With respect to radioactivity, though, the statement is correct. It would have been difficult indeed for any literate person to miss making the acquaintance of this word, in any year since 1900. I might say that radioactivity has been the best-advertised topic in modern physics—and this is not to say that it has been over-advertised! It is in fact the only part of modern physics which has received something approaching its due renown. Such good fortune cannot of course be altogether due to the fundamental values of the subject. A great part of the fame of radioactivity comes from medical applications and even more from medical hopes, and some from incidental things, such as the tragic end of one of its great students and the sex of two others. Still it is a matter for rejoicing that whatever the reasons may be, one portion of physics now enjoys its proper quota of the glory to which so many others are entitled.

The discovery of radioactivity took place in 1896. Quite a number of things of the highest importance to physics—and to humanity at large—were begun between 1895 and 1900, and of these the study of radioactivity was the second. The study of X rays was the first. The second was commenced only because the first had been, and therefore I speak of the first. Imagine a tube containing air and a couple of electrodes a few inches apart, and suppose that you have a battery which can supply a durable current at 10,000 volts or more, and an air pump as well. If the air is at atmospheric pressure, the 10,000 volts can be applied between the electrodes and nothing will happen. If with the pump you now reduce the pressure of the air to about a thousandth of the atmospheric value, the air which remains in the tube will become very luminous and splendid. If next you reduce the air pressure by yet another tenfold, the splendor will fade out, but now the glass of the tube itself, in the region opposite the negative electrode, will be shining with a pale green glow. This too is a beautiful sight, but decidedly not one to be enjoyed for a long time at close range, for it is attended by invisible rays very dangerous to health and even life. These are the X rays.

Many people have heard that Roentgen discovered the X rays because he kept some photographic plates in a box which happened to lie near the tube, and found one day that the plates were fogged. It is true that he did observe the fogging of plates by the rays; it is true also that for years afterward, people were telling in various parts of Western Europe and America how they too had noticed that their plates were spoiled when left by accident in the neighborhood of discharge tubes, but unluckily they had only felt annoyed and had resolved to keep their next batches of plates in safer places. However it was something else that led Roentgen to the discovery. He had in his laboratory some sheets of phosphorescent substances; and he found that whenever one of them was in the neighborhood of the tube it would shine; and what was more, *it would shine even when hidden from the tube by a sheet of black cardboard.* The X rays (as he presently named them) were able to pierce substances opaque to light, and to cause phosphorescent substances to shine. Roentgen very soon discovered other properties of the rays, but these were the earliest. Moreover the greenish glowing of the glass in the X-ray tube itself resembles the light of phosphorescence; so, here were two apparent connections between penetrating X rays on the one hand, and phosphorescence on the other.

Now we come to radioactivity. There was a man in Paris whose attention was caught by these facts, and his name was not Curie. Curie is the second great name in the story of radioactivity; the first is Becquerel. I put down his first name (Henri) as well, for Becquerel—like Curie and Bernoulli and Darwin and others—is the name of a dynasty of scientists, of which Henri was the third. Henri Becquerel seems to have reasoned after this fashion: "X rays and phosphorescence are found together; therefore, wherever there is phosphorescence, there may be rays like X rays." So he took photographic plates and wrapped them in dark paper, and then he took one phosphorescent substance after another and (after making them luminous by exposing them to light) laid them in succession beside the plates, and after an interval looked to see whether there had been fogging. Time after time the result was completely negative, but at last he came upon a chemical compound of the element *uranium* which was phosphores-

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An address delivered before the New York Electrical Society, January 12, 1938, and scheduled to be delivered at the AIEE North Eastern District meeting, Lenox, Mass., May 18–20, 1938.

K. K. DARROW is research physicist of the Bell Telephone Laboratories, Inc., New York, N. Y. He received the degree of bachelor of science from the University of Chicago in 1911 and doctor of philosophy from that institution in 1917. During 1911 and 1912, he studied at the Universities of Paris and Berlin. Since 1917 Doctor Darrow has been in the employ of the Western Electric Company and Bell Telephone Laboratories. He has been engaged largely in writing on various fields of physics and the allied sciences.

Figure 1. Periodic table of the elements

Values of atomic weights taken from the seventh Report of the Committee on Atomic Weights of the International Union of Chemistry; G. P. Baxter and others, *Journal* of the American Chemical Society, volume 59, page 219

I	II	III	IV	V	VI	VII	VIII	O
1 H 1.0078								2 He 4.002
3 Li 6.940	4 Be 9.02	5 B 10.82	6 C 12.01	7 N 14.008	8 O 16.000	9 F 19.00		10 Ne 20.183
11 Na 22.997	12 Mg 24.32	13 Al 26.97	14 Si 28.06	15 P 31.02	16 S 32.06	17 Cl 35.457		18 A 39.94
19 K 39.096 29 Cu 63.57	20 Ca 40.08 30 Zn 65.38	21 Sc 45.10 31 Ga 69.72	22 Ti 47.90 32 Ge 72.60	23 V 50.95 33 As 74.9	24 Cr 52.01 34 Se 78.96	25 Mn 54.93 35 Br 79.916	26 Fe 55.84 27 Co 58.94 28 Ni 58.69	36 Kr 83.7
37 Rb 85.48 47 Ag 107.880	38 Sr 87.63 48 Cd 112.41	39 Yt 88.92 49 In 114.76	40 Zr 91.22 50 Sn 118.70	41 Nb 92.91 51 Sb 121.76	42 Mo 96.0 52 Te 127.61	43 53 I 126.92	44 Ru 101.7 45 Rh 102.91 46 Pd 106.7	54 Xe 131.3
55 Cs 132.91 79 Au 197.2	56 Ba 137.36 80 Hg 200.61	Rare Earths 81 Tl 204.39	72 Hf 178.6 82 Pb 207.21	73 Ta 180.88 83 Bi 209.00	74 W 184.0 84 Po	75 Re 186.31 85—	76 Os 191.5 77 Ir 193.1 78 Pt 195.23	86 Rn 222
87—	88 Ra 226.05	89 Ac	90 Th 232.12	91 Pa 231	92 U 238.07			

Rare Earths

57 La 138.92	58 Ce 140.13	59 Pr 140.92	60 Nd 144.27	61	62 Sa 150.43	63 Eu 152.0	64 Gd 156.9
65 Tb 159.2	66 Dy 162.46	67 Ho 163.5	68 Er 167.64	69 Tm 169.4	70 Yb 173.04	71 Lu 175.0	

cent and which fogged the plate. It is not recorded that he shouted "Eureka!" but he had as good reason to do so as Archimedes. He had discovered the first-to-be-known example of radioactivity.

Now comes the strange and paradoxical part: Becquerel had arrived at his great discovery by following a false clue. There is really no connection whatever between radioactivity and phosphorescence, and it was purely an accident that a compound which was phosphorescent had happened to contain an element which was radioactive. In trying to make a simile for what then happened, I have adopted the rather frivolous comparison which follows. Suppose that you were to meet a man who was wearing a blue serge suit, and notice that he was speaking a foreign language—Swedish, let us say. For some reason this would interest you particularly, and you would decide to look for other examples of people speaking Swedish. You would begin by reasoning that "Swedish speech was associated with a blue serge suit, and therefore any man who is wearing blue serge may speak Swedish." You would then listen to everyone whom you passed in the street who was wearing blue serge, and the first few whom you heard would prove to be speaking English. This would prevent you from believing that a blue suit necessarily entails the speaking of Swedish; but you might continue anyhow, and eventually you might find another man who was wearing blue serge and speaking Swedish. Now if you were like some people, I am afraid you would send a communication to a scientific journal, announcing that it is a principle that everyone speaking Swedish is wearing a blue serge suit. But not if you were like Becquerel! If you were like Becquerel you would trail the man for weeks; and sooner or later you would come upon him wearing a grey suit or a brown one, and still he would be speaking Swedish. In the course of time you would doubtless come upon other people who never wore blue serge and yet spoke Swedish. Finally you would realize that it was just a piece of luck that you had happened to discover a man speaking Swedish, by making the fallacious assumption that all such men wear blue. Now in this case of Becquerel's, the phosphorescence was only a feature of the clothes which the uranium happened to be wearing, or more literally, the chemical compound in which it was involved. But the radioactivity was a feature of uranium itself and that is what Becquerel proceeded to prove; first by testing various other chemical compounds of uranium which were not in the least phosphorescent, and then by testing the pure uncompounded metal itself.

Uranium, then, is a radioactive element. But it is not the only one; there were numerous others, even in the days before the physicists had started making new ones. This is where the elder Curies enter the story: Pierre and Marie Curie, in 1898. First they measured the activity of uranium, pretty carefully. Then they started measuring the activity of various minerals containing uranium, and they found too much: these minerals were more active than they should be, by virtue of their uranium content alone. The Curies suspected that some other radioactive element was lurking in the depths, and they undertook to get it out. This was of course a chemical problem primarily, and as a matter of fact, their Nobel prize was the chemistry prize, and quite rightly. Eventually they isolated their new element, or rather, two of them, which they named "polonium" and "radium." Having at last got their radium and weighed it, they found that it amounted to only two parts in a hundred million (by weight) of the rock from which they had extracted it. They required three tons of the rock, in order to get one one-hundredth of an ounce of the radium. Two parts in a hundred million! and yet, while it was still dispersed in that almost incredible scantiness through the rock, they had already been able to detect it! This is the point which

I most wish to bring out, at this stage. A radioactive substance is far more easy to detect than any which is not. It is like salt in food, and the radioactivity is like the flavor of the salt, which shows the presence of a dash so insignificant that anything else in the food would go untasted if it were equally rare. Fortunately for us the instruments which are used to detect a radioactive body are not our tongues, but apparatus of a much less vulnerable kind.

Now I mention only one name before reaching the recent developments, but this the greatest name of all: RUTHERFORD. Rutherford was the first to understand radioactivity—the first to prove the contemporary atom-model—and the first to achieve transmutation. Any one of these achievements by itself would have secured undying glory to its author, but this great man made three. As lately as two years ago I wrote in a book that every leading figure in the history of transmutation was still living and still ardently at work. As lately as last October I could have repeated that, but now the master is gone—quite suddenly gone in the fullness of his powers. This lecture is in a sense a memorial to Rutherford, not because it was so designed, but because any lecture on the new radioactivity or on the old involves so much of his thought and so much of his work that it would be reduced to a few incoherent bits if everything not traceable to Rutherford should be left out.

The first achievement of Rutherford in this field was to identify the rays emitted by radioactive bodies. He identified three kinds, and gave them the names which they still bear and assuredly always will: *alpha*, *beta*, and *gamma* rays. The last-named (which are of the nature of light) are the ones whereby radioactivity was first detected, for they are the ones which fog the plates and produce the phosphorescence outside of a rather narrow space just around the radioactive substance itself. They are also the ones responsible for the great work already done in medicine by radioactive bodies, and on which (I am told) there is great reliance for the future. If this were a medical lecture the gamma rays would require most of its content; but as it is not, I leave them with this brief allusion, and turn to the others. The beta rays are electrons, which may be of either sign (Rutherford, like the rest of the world, was acquainted only with the negative ones until five or six years ago). The alpha rays are also charged particles, much heavier than electrons; I shall be defining them more exactly before long. The beta rays and the alpha rays, and for that matter the gamma rays as well, are detected by very ingenious devices of which most types are electrical, though the particular type which supplies the photographs seen in this lecture is not.

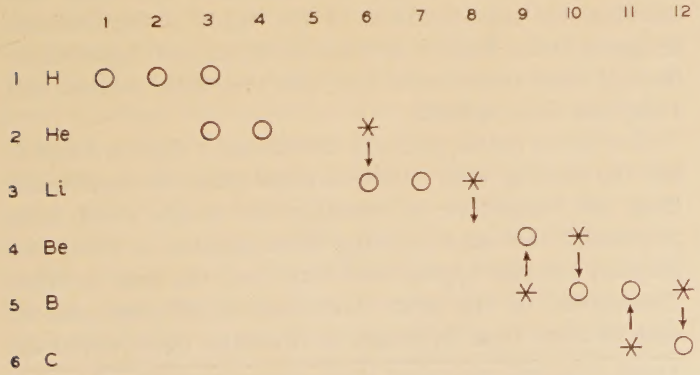

Figure 2. Isotopes of the first six elements

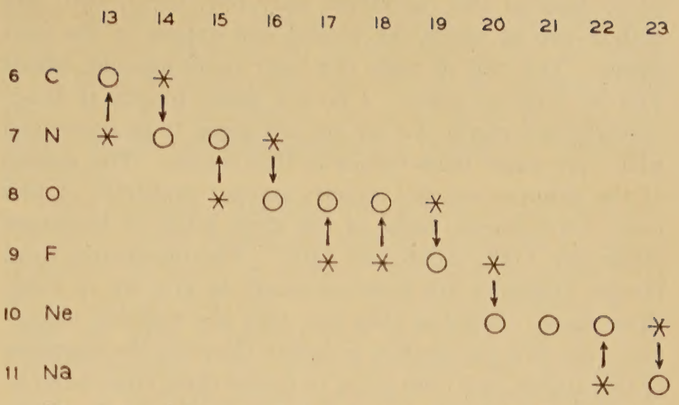

Figure 3. Isotopes of the elements numbered 6 to 11

Now at last I exhibit the list of the radioactive elements.

This list (figure 1) is none other than the veritable table of the elements itself! *Of all the known elements there now remains just one of which no radioactive form has yet been discovered or invented.* Hydrogen is the exception (the reader may say "Of course!" but it is not excluded that some day a radioactive type of hydrogen may be produced.) At the end of the list stands uranium, the first of the radioactive bodies to be discovered. It has stood there ever since Mendeleff set up the table in this fashion, but actually it now must yield its pride of place, for physicists have lately created radioactive elements which lie beyond it. I have though gone ahead too rapidly in speaking of these already. Once more let me state the marvelous fact that of all the known elements, every one but hydrogen exists in a radioactive form, many indeed in more than one.

In speaking of "forms" I have been alluding to something which the table as it stands in figure 1 does not make clear. Everyone recognizes the "chemical atomic weights" there appended to the symbol of each element. If an element has only one kind of atom, this figure is the actual mass of the atom, expressed in terms of a unit which I will presently define. There are such elements; beryllium and fluorine, sodium and aluminium are examples. Most elements however have two or more kinds of atoms differing in mass. Thus, in figure 1, the pigeonhole for hydrogen should contain three mass-values; that for helium, two; that for tin, no fewer than ten. It would make the table impossibly crowded to print them all in this way, and consequently I have broken it up into sections, of which figure 2 represents the first six elements.

In this figure each element has a row to itself, and each value of mass has a column to itself, and each circle represents a stable kind of atom. I now introduce the technical term "isotope" to distinguish the different kinds of atoms common to a single element. Hydrogen, you see, has three stable isotopes (there is some doubt about the stability of the third, though none about its existence); helium two (again there is doubt about the stability of one); lithium two, beryllium only one, boron two, and carbon two of which the second will appear in the next figure. The unit of mass is a very small amount, about $1.67 \cdot 10^{-24}$ of one gram. I do not pause to give it as accurately as I might, for we are not going to be concerned with very exact mass-values in this article. The masses of the isotopes are not exactly integer multiples of this unit; for instance, those of the three kinds of hydrogen atoms are 1.008, 2.016, and 3.017. The departures from integer multiples are however small, as you see in these three cases. Small as they are, they are mightily important; but it is permissible to ignore them for the purposes of this article, and I am going to ignore them from now on. I will however write of the integers at the heads of the columns as "mass-numbers" rather than "masses."

Since the isotopes of an element differ in mass, what is it then that they have in common? I answer this question by describing Rutherford's second great achievement, the "nuclear atom-model." Rutherford was the first to prove that the atom consists of a positively-charged nucleus surrounded by a swarm of negative electrons. The nucleus is much more massive than the electrons, and this is one of the reasons for comparing the atom with the solar system, in which the sun is much more massive than the planets which perpetually swing in orbits around it. A less hackneyed and newer simile is that of Bragg (just now, by the way, appointed as Rutherford's successor in the Cavendish chair at Cambridge) who likens the atom to a man's head with a swarm of gnats buzzing around it. Normally—that is to say, when the atom is complete and electrically neutral—the negative charges of all the electrons put together just balance the positive charge of the nucleus. If Z be used to stand for the number of electrons in the normal neutral atom, and $-e$ for the charge of the negative electron, then $+Ze$ is the amount of the charge on the nucleus. Z is called the "atomic numbers" of the element in question. This it is, of which all the isotopes of any one element have the same value. This it is which distinguishes an element, and is common to all of the different atoms of that element whatever their masses may be. For hydrogen it is 1; for helium 2; for lithium 3; for uranium 92. Each row in figure 2 and figure 3 is marked on the left not only with the chemical symbol of the element to which the row belongs, but also with the atomic number thereof.

Radioactivity is a feature of the nucleus. This accounts for some of its remarkable aspects, which greatly surprised the world of physicists and chemists when they were first established. Being a quality of the nucleus, it varies from one isotope* to another of any element, much more drastically than does the mass. Being a quality of the nucleus, it is immune to the physical state of the atom—i.e., it is the same whether the atom is part of a solid, a liquid, or a gas; it is immune also to the chemical state of the atom, i.e., it is the same whether the radioactive element is isolated or is part of a chemical compound. It is also immune to heat and to all of the many other agencies which physicists and chemists have at their command.

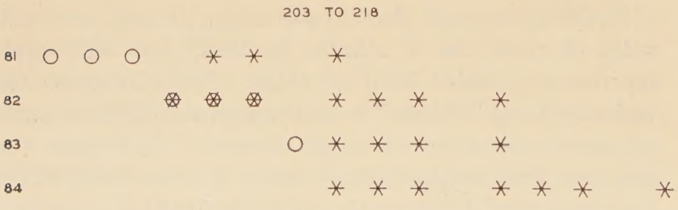

Figure 4. Isotopes of the elements numbered 81 to 84

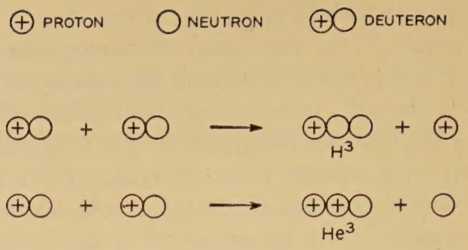

Figure 5. Scheme of the deuteron-deuteron reactions

Radioactivity being a feature of the nucleus, every chemical symbol which I use from now on will refer to the nucleus of an atom and not to the atom as a whole. "Be" will stand for beryllium nuclei, "F" for fluorine nuclei, "Al" for aluminium nuclei. For most elements, though, there are two or more different sorts of nuclei distinguished from each other by their masses, and the symbol must tell us which is meant. The custom is to write the mass-number of the isotope in question as if it were an exponent: H^1 and H^2 and H^3 for the three kinds of hydrogen nuclei, He^3 and He^4 for the two kinds of helium nuclei, Li^6 and Li^7 to distinguish between the isotopes of lithium, and so on. If in addition one wants to remind the reader of the atomic number, one writes it as a subscript before the chemical symbol: ${}_1H^1$, ${}_1H^2$, ${}_2He^4$, ${}_9F^{19}$ and the like. Purists object that either the chemical symbol or the value of Z is superfluous when both are given, but others often like to see them both. And now for some names: there are three nuclei which have names of their own. The Greek words for "first" and "second" are applied to ${}_1H^1$ and ${}_1H^2$; they are the *proton* and the *deuteron*. The name for ${}_2He^4$ is *alpha particle;* this nucleus is indeed the particle which, as Rutherford discovered long ago, makes up one of the three kinds of rays which radioactive bodies emit, and there never was a greater piece of good fortune in language than that whereby this all-important particle received the name of the first letter of the Greek alphabet, for indeed it is the alpha of modern nuclear physics. And now another reference to masses: the mass of the electron (when not moving extremely fast) is only about 0.0005 of the mass-unit which is being used throughout this talk, and therefore the mass-numbers at the heads of the columns in figures 1 and 2 and others are about as good approximations to nuclear masses as they are to atomic masses, and I shall use them as such.

Now let us notice not only the circles of figures 2 and 3, but the stars as well. The stars also stand for nuclei, but these are *radioactive*—or *unstable*, two words which have practically the same meaning when applied to a nucleus. At least one star appears in every row, the first in figure 2 excepted. If the figure had room for 92 rows, one for each element from hydrogen to uranium, there would ap-

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* Isotopes were first distinguished from each other (by Soddy) by virtue of their differences in radioactivity.

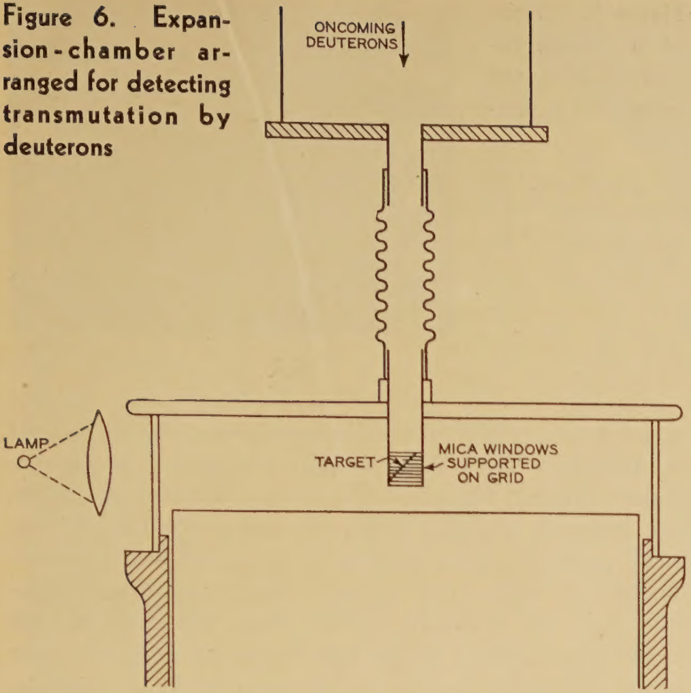

Figure 6. Expansion-chamber arranged for detecting transmutation by deuterons

pear at least one star in every row below the first, excepting three (atomic numbers 61, 85, 87) for which no isotope either stable or unstable is known with certainty and the element itself must still be regarded as missing. (Furthermore there should be at least three more rows numbered 93, 94, and 95, and containing stars but no circles.) This is what is meant by saying that every known element, hydrogen alone excepted, has at least one radioactive form.

Figure 2 shows that at the beginning of the table of the elements, the stable types of nuclei outnumber the unstable ones. The preponderance is gradually shifted as Z increases, and figure 3 exhibits to us how greatly the radioactive nuclei outnumber the stable ones among the elements of which the atomic numbers range from 81 to 84. Indeed the circle which is lowest and most to the right in figure 3 represents the most massive and most highly charged of all the stable nuclei which are known (it is the solitary isotope of bismuth, atomic number 83 and mass-number 209). All the rows after 83 are occupied entirely by stars.*

As the title of this article has already suggested, the radioactive nuclei are of two classes: the "natural" and the "artificial," the types already existing in the rocks of the earth and the types made in the laboratory by physicists employing the art of transmutation. Nearly all of the natural types lie beyond 80 in atomic number, and most of them were discovered in the first 15 years after Becquerel found the first. Two of them are identical with two of the man-made types. Apart from these two, every one of the artificial types is a creation of the years since 1933. One guesses that while the natural radioactive bodies may be many, the artificial ones must surely as yet be few; how surprising then to learn that while there are some 40 of the former, the latter after four brief years already number 230! Unlike the natural ones, these artificial isotopes are sprinkled liberally throughout the whole of the table of the elements, from the second onward to the end. Not only in number but in diversity of mass and charge are the artificial radioactive bodies now outstanding by far.

These artificial examples forming now so large and important a group among the radioactive nuclei, I make a digression to speak of some of the transmutations from which they are derived. The art of transmutation is already so huge a subject that the digression must be severely limited if ever we are to come back to radioactivity. I must therefore make only a passing allusion to the fact that the first of the new radioactive nuclei were made by bombarding various light elements with very energetic alpha particles. Here the second Curie generation must be introduced, for the daughter and son-in-law—Irene Curie and Frederic Joliot—of the first Curie pair were the ones who made this discovery. (It was not their entry into the field of radioactivity, they having already studied natural radioactive bodies for a number of years).

Returning to figures 2 and 3, notice that many of the radioactive isotopes lie just one step to the right of stable isotopes: Li^8, Be^{10}, B^{12}, C^{14}, N^{16}, O^{19}, F^{20}, Ne^{23} are the examples found in these two pictures alone. It seems as though they might differ from their neighbors on the left—Li^7, Be^9 and so forth—by possessing an extra particle of mass (approximately) 1 and charge zero. If only one could find such particles roaming freely about in nature, might one perhaps succeed in adding them to the stable nuclei of lithium and beryllium and boron and the other elements and so produce these radioactive nuclei?

Such particles may indeed be found roaming about in nature, but not of their own volition. These "neutrons"—for such is their name—must themselves be set free by the art of transmutation. Free neutrons were first produced by bombarding certain elements with alpha particles; the discovery was an international one, and its story is interesting, but to keep this digression within bounds I

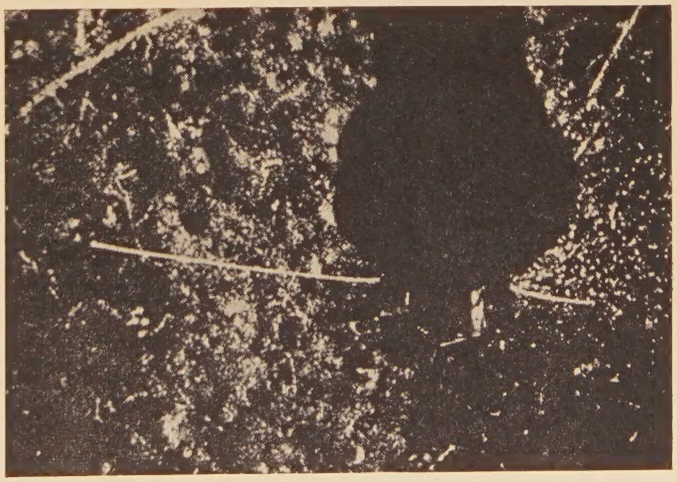

Figure 7. Tracks of a proton and a H^3 nucleus resulting from one of the deuteron-deuteron reactions

(P. I. Dee, Cavendish Laboratory; *Proceedings* of the Royal Society) must again content myself with giving the names—Bothe and Becker in Germany, Curie and Joliot in France, Chadwick in England—of those who carried it through its consecutive stages from first intimation to triumph. More than 100 different ways of freeing the neutron are already known, but of all this diversity I will take one only, which consists in projecting deuterons against deuterons.

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* It must though be admitted that some of the heaviest nuclei, though demonstrably radioactive, may exist for hundreds of millions of years before they disintegrate; "instability" is indeed a very relative concept!

The "deuteron-deuteron reactions"—D-D reactions for short—are produced by applying high voltage to deuterons (emerging from a discharge tube containing heavy hydrogen, in which some of the atoms are divested of their electrons and the nuclei are left bare) and then directing them across a vacuum against a target containing other deuterons. (The target may be some solid compound of heavy hydrogen, such as ice in which plenty of the hydrogen atoms belong to the isotope H^2; or it may be gaseous heavy hydrogen.) The high voltage is required, so that the impinging deuterons may override the electrostatic repulsion between the positive charges which they bear and the positive charges of the deuterons waiting in the target and come into contact with these last. Generally in transmutation, "high voltage" signifies volts by the millions. These particular reactions are however among the easiest to produce, and with less than 100,000 volts it is quite possible to liberate neutrons at such a rate that their peculiar qualities can be well studied. (One reaction indeed has been detectably produced at 8,000 volts, a figure so low that it arouses speculation as to what the course of physics might have been if the second isotope of hydrogen had been discovered say 30 years ago.)

To explain what is actually observed to happen, I ask the reader to imagine the deuteron as a composite of a proton and a neutron, as it is exhibited in figure 5. With this image in mind, one might well expect that when deuterons are hurled with great energy and speed against a plate of matter containing massive nuclei—lead, for instance—they would be broken in two. This has been sought for but apparently does *not* happen, showing that we must keep our imaginations under continual check by experiment. What *does* happen is displayed, for the impacts of deuteron against deuteron, in figure 5. It seems that one deuteron is after all broken in two, but only under the condition that either its component proton or its component neutron adheres to the other. Another metaphor: one deuteron snatches either the proton or the neutron away from the other, leaving the abandoned neutron or proton to go free. Both of these descriptions are too figurative, but what is certain is this: from the scene of such impacts, particles of all the four kinds shown to the right of the arrows in figure 5 are observed to be proceeding. The labels show (what should already be obvious) that the newborn particles of mass 3 are isotopes of hydrogen or helium, according as they contain two neutrons and one proton or two protons and one neutron. I now show pictures to support these statements.

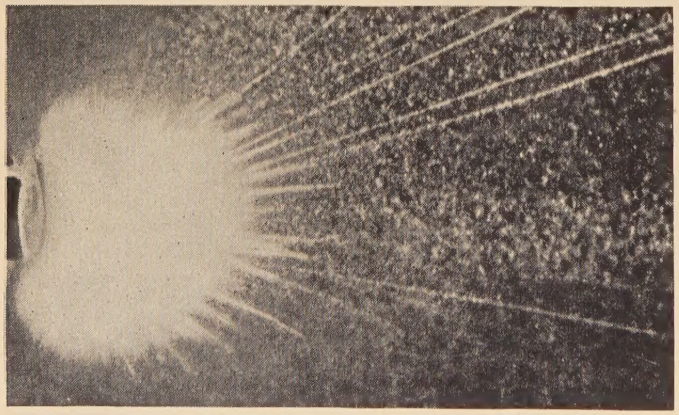
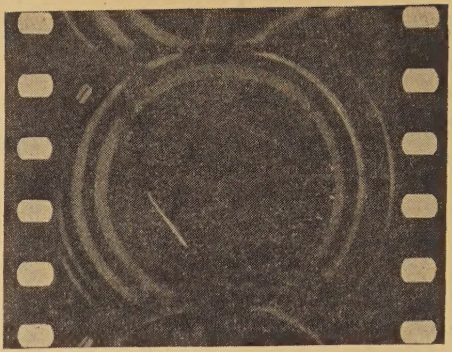


Figure 8. Tracks of protons, H^3 nuclei and He^3 nuclei resulting from the two deuteron-deuteron reactions

(P. I. Dee and C. W. Gilbert, Cavendish Laboratory; *Proceedings of the Royal Society*)

Figure 9. Track of a proton recoiling from the impact of a neutron

(I. Curie and F. Joliot, Institut du Radium; *Journal de Physique*)



In figure 6 the apparatus is shown in a sketch: the cloud chamber or expansion chamber of C. T. R. Wilson, being the hollow cylinder which is shown below in axial section, its top being a glass plate and its bottom a piston head which can be pulled very suddenly downward by mechanism. Ordinarily the chamber is filled with moist but dustless air; when the piston head suddenly drops the air and the water vapor are sharply cooled by expansion, and the vapor condenses in droplets upon whatever ions may be floating in it. The side tube which enters the chamber from above is evacuated; through it come the impinging deuterons, to make their impacts upon the target at the knob-like closed end of the tube. The wall of the tube, thin as it may be made, is too thick to allow the deuterons to emerge into the air of the chamber. One might well expect that *a fortiori*, any new particles born out of the transmutation would be too slow-moving to pierce the wall; but many of these particles are much more energetic than the impinging deuterons themselves, for they draw upon a reserve of energy stored up in the nuclei.* They shoot through the wall into the air of the cloud chamber itself, and if they are charged, they make long trails of ions along their paths. The expansion is then produced and the water vapor, condensing upon these ions, makes trails of droplets which are the paths made visible.

Figure 7 exhibits two of these visible paths of "tracks," made by particles which sprang from the scene of the transmutation (inside the knob) in practically opposite directions but with very different penetrative powers, since one of the tracks is seen to be much longer than the other. The long one is the track of a proton, the short one is that of a H^3 nucleus which is a deuteron augmented by a captured

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* In the sense employed in chemistry, these are "exothermic" reactions.

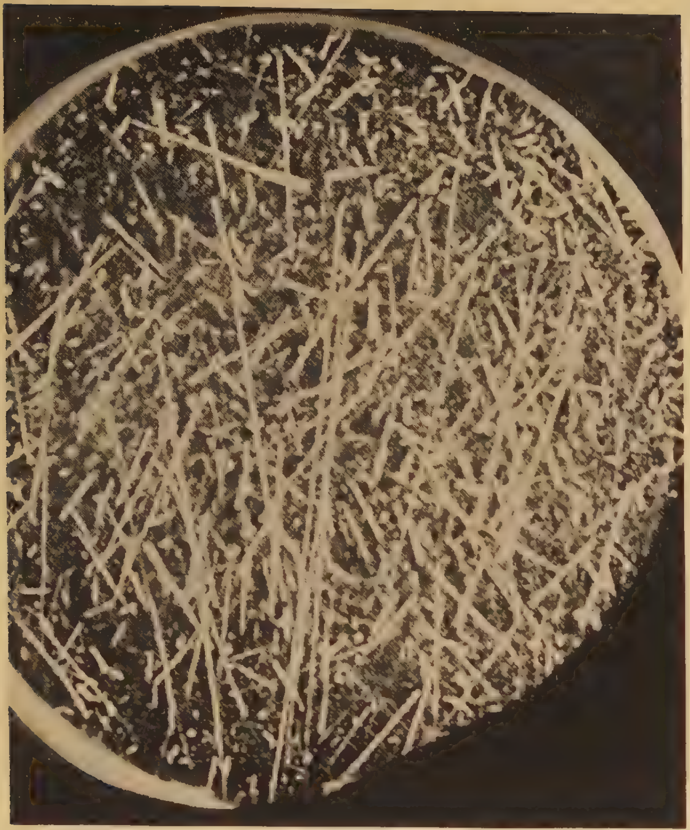


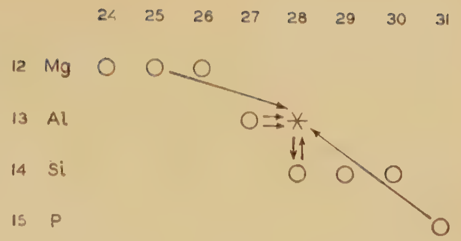
Figure 10. Tracks of protons recoiling from impacts of a dense stream of neutrons

(F. N. D. Kurie, University of California)

neutron: this picture shows a single example of the upper reaction of figure 5. How can physicists be sure that these tracks are due to the nuclei which I have named? This question is far too deep to be answered in this place, and I can only assure the listener that while such pictures by themselves cannot suffice for the proof, an unassailable proof can be and has been given by other and electrical methods of observing these newborn particles.

But how about the lower reaction of figure 6—the one which really concerns us, since all this digression is designed chiefly to exhibit the origin of free neutrons? In figure 7 no track appears which can be attributed to either a He^3 nucleus or a neutron and no such tracks appear in other similar pictures. The absence of He^3 is however due to a simple cause: these nuclei are born with insufficient energy to traverse the wall of the tube. To observe their tracks it is necessary to suppress the tube end, to fill the expansion chamber with heavy hydrogen in the gaseous form, and to project the deuterons directly into it. When this is done, all of the region of the gas which the impinging deuterons can reach becomes completely filled with the ions formed along their many tracks, and appears as a flare on the photograph (figure 8). Out of the flare project the tracks of the newborn nuclei. Those which stretch clear across the picture are in part those of protons, in part those of H^3 nuclei born from the first reaction. But in addition one sees a number of short tracks which terminate not far from the edge of the flare itself. These are the tracks of He^3 nuclei—not merely guessed, but proved, to be such.

Figure 11. Various ways of making the radioactive nucleus Al^{82}



Where however are the tracks of the neutrons? They are not seen upon this picture, nor in any; for neutrons make no tracks. Neutrons bear no electric charge, and hence they do not ionize the molecules of the air or any gas as they go through, for ionization is effected only by electrical forces which can tear electrons out of their places in molecules. Not making ions, they afford no footholds whereby the water vapor can condense and mark their passage. The expansion chamber is frustrated; and worse yet, so are the electrical devices which serve for detecting charged particles like fast protons or fast electrons, since they too depend on the ions which these can make. The neutron indeed might slip through all of our apparatus completely undetected, were it not liable to make collisions with nuclei so sharp and sudden that they may be compared with impacts of one billiard ball upon another. Comparisons with billiard balls are rife in physics, but seldom with so much justification. When neutrons are streaming through a gas, such impacts are suffered by nuclei of occasional atoms of the gas; and like a struck billiard ball, they recoil, and in recoiling they are able to make ions and the ions then serve to reveal them.

The track of such a recoiling nucleus, made visible in a cloud chamber, is seen in figure 9. This was taken soon after the discovery of the neutron, and at a time when these particles had as yet been released only by using natural radioactive substances to project alpha particles against various targets. Such ways of producing free neutrons are not very efficient, and accordingly one sees in the whole expansion chamber one track and one only (though I must interpolate that according to our present knowledge, many thousands of neutrons must have traversed this chamber without happening to strike any nucleus). See now the contrast with the present time, as illustrated by figure 10 which shows an expansion chamber traversed by the neutrons released when deuterons from a high-voltage machine bombard a target.* The machine in question was the famous cyclotron of E. O. Lawrence: there is no more striking illustration of the powers which this instrument has conferred upon the scientific world, over and above those which radium has already granted.

Our digression now ends, and we return to the artificial radioactive substances, being now equipped with knowledge as to how these—or rather, many of them—can be made. As I said earlier, many radioactive isotopes differ from existing stable isotopes only in possessing an extra neutron in the nucleus; and this extra neutron can be supplied to the stable nucleus, combining it and converting it into the radioactive type. I have just exhibited one way in which the extra neutron may be, and often is, supplied. In the first-mentioned of the deuteron-deuteron reactions, a neutron is taken away from one of the deuterons by the other, which latter is thus converted from H^2 into H^3. There are many stable isotopes, of many elements, which are able to take away neutrons from impinging deuterons in this manner; a recent list gives no fewer than 50. The resulting nucleus-types are not in every case radioactive; several are stable, including H^3 itself (at least, no one has yet discovered evidence that H^3 is unstable, though there are doubts about it). Most however *are* radioactive. The reactions in question are known as *(d,p)* reactions, in allusion to the fact that deuterons enter the target and protons spring out. One might imagine that the deuteron consists of a proton leading along a neutron, which it pushes into the nucleus which it strikes, itself continuing its career as a free particle.

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* This was another reaction than the one just mentioned, the target being of beryllium.

Neutrons however do not have to be escorted into nuclei by protons; those which are already free, such as the ones which are released in the second of the D-D reactions, are quite well able to creep in themselves and make themselves permanently at home. My use of the verb "creep" is not entirely fanciful, for the slower the neutrons are moving as they approach a target, the better their chance of entering its nuclei. Those fresh from their origin in reactions of transmutation are usually moving much too rapidly to be able to come to a halt in a nucleus—or to be liable to capture, whichever way of putting it one may prefer. It is necessary to interpose, between the source and the target, a block of paraffin or a can of water several inches thick. If the source consists of a natural radioactive substance bombarding another element with alpha particles and thus releasing free neutrons, the two may be mixed with each other and enclosed in a capsule which is then embedded in the center of a paraffin sphere or immersed in water. As the neutrons make their way out, they collide again and again with the nuclei of atoms in the paraffin or the water, and these recoil from the impacts. It is not however their recoiling which is now of importance, but the fact that at every such impact the neutron loses some of its energy. The point about choosing water or paraffin is that they are rich in hydrogen and consequently full of protons, and the elastic impacts of the neutrons against these entail a greater average loss of neutron-energy per collision than do impacts against any other nuclei.* There is good reason to believe that most of the emerging neutrons have energies no greater than those which the atoms of the water or the paraffin possess by virtue of their thermal agitation. These are the neutrons which are most effective in converting stable into radioactive nuclei by letting themselves be captured.

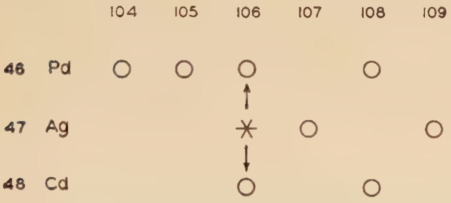

Figure 12. Illustrating an example of isomers

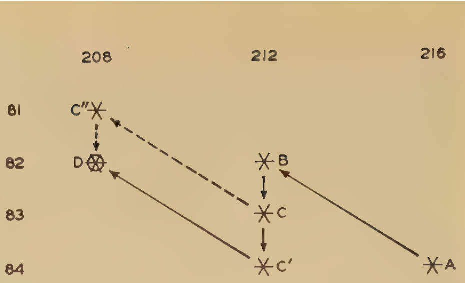

Figure 13. Part of the thorium series of radioactive nuclei. To make the sketch correspond to the actinium series, imagine each star moved one unit to the left

Even yet I have not mentioned all of the ways in which radioactive substances can be and are being made. Time does not suffice for commenting on the others, but some are exhibited in figure 11, which displays all of the stable but only one of the unstable isotopes of the four elements numbered 12 to 15. This one radioactive type, which I have tried to make more conspicuous by leaving out the rest, is the isotope 28 of aluminium—one of the few elements, which, very conveniently for physicists, has one stable isotope only. The arrows converging onto the star show the different ways in which Al^{28} is made. The two coming from the left signify that it is made by adding a neutron to the stable isotope Al^{27}; there are two of them, because the Al^{27} nucleus can either absorb a slow free neutron or annex the neutron from an impinging deuteron, whichever it has the opportunity of doing. The arrow slanting downward from the left signifies that Al^{28} can be made by bombarding magnesium with alpha particles: some of these are absorbed by nuclei of the isotope Mg^{25} which thereupon at once emit protons. The arrow slanting upward from the right signifies a process in which phosphorus is bombarded by neutrons (fast ones, in this case!) and some are absorbed by the nuclei P^{31} which thereupon eject an alpha particle apiece. The arrow pointing straight up signifies a process in which silicon is bombarded by neutrons; some are absorbed by nuclei Si^{28}, which instantly throw out protons. With no fewer than five ways of making a single radioactive type at his command, the physicist is in a position of power which seems all the more remarkable when one recalls that as lately as five years ago he had not (knowingly) made any radioactive substance by any way whatever.

Consider now the arrow pointing away from the solitary star in figure 11, and the arrows pointing away from the many stars in figures 2 and 3. These signify what is really meant by calling an isotope "radioactive." *A radioactive nucleus is one which spontaneously changes itself into a nucleus of another element by emitting a charged particle.* (Usually it lasts an appreciable time before it does so, and this delay is to be mentioned in a complete definition of the word "radioactive".) The arrows pointing away from the stars will serve to specify these changes. All in these figures are vertical: every one of these unstable isotopes transforms itself by emitting a particle of which the mass is very small (compared to the mass-unit which we are using) while the charge is $+e$ or $-e$, according as the transformation is to the element preceding or to the element following. These particles are positive and negative electrons. All of the man-made unstable nuclei are radioactive after this fashion, being electron-emitters; and so are more than half of those which are found in nature.

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* Energy transfer between an initially-moving and an initially-stationary elastic sphere is greatest when the latter is of the same mass as the former, and for protons and neutrons this equality of mass is realized within 0.1 per cent.

What decides whether it shall be a positive or a negative electron which a given nucleus-type emits? Physicists cannot explain this as yet, in any adequate sense of the verb "to explain"; but we can readily see the law which governs the choice by examining the pictures. In figures 2 and 3 it will be seen that from each star the arrow points in whichever sense—upward or downward—it finds a circle to point at. Becoming completely animistic for the moment, I may say that the unstable nucleus wants to be stable—knows that one of its two neighbors, of identical mass-number but greater or lesser charge, is stable—knows *which* of the two is stable—and deliberately proceeds to identify itself with its stable neighbor by emitting an electron of the necessary sign. Putting the situation more drily: each of these unstable nucleus-types tends to transform itself into its adjacent stable isobar. Here "isobar" is a technical term for "nucleus of the same mass-number," and "adjacent" is a short way of saying "belonging to the preceding or the following element."

Suppose the star has circles both above and below it, i.e., that both of the adjacent isobars are stable (and prove themselves so by existing in nature): how will the unstable nucleus resolve its dilemma? Such cases are rare, but not entirely absent. An example appears in figure 12. The elements palladium and cadmium have isobaric isotopes of mass-number 106, in spite of the fact that their atomic numbers (46 and 48) are not consecutive: silver, with atomic number 47, lies between. There is no stable silver isotope 106, but a radioactive one can be and has been created, and for this the dilemma is posed. It handles the dilemma by grasping both horns! Electrons of *both* signs come out of the radioactive silver. I must say that there is something which indicates that the nuclei which make one choice may be slightly different (in mass, for instance) from those which make the other. It may therefore be well to speak of silver as having two isotopes of the same mass-number 106, and a word has already been coined: they are called "isomers" of one another. This does not alter the fact that where alternative choices exist, both are elected.

On figure 2 we notice an arrow which points to a vacancy. No stable nucleus Be^8 is known, though there has been a very diligent search for it conducted by many ways in many places. Practically no doubt exists that Be^8 bursts of itself into two pieces (two alpha particles) almost as soon as it is made. We thus have here an unstable (radioactive) nucleus—Li^8—which does *not* find stability by ejecting an electron, but instead hastens onward to a completer ruin. In the lower reaches of the table of the elements there are so many stable isotopes that the unstable ones can almost always turn themselves by one electron emission into one or another of these, and such catastrophes are rare. Among the natural radioactive substances in the upper reaches of the table they are common, as I now show in returning to natural radioactivity for the close of this article.

Notice again figure 4, in which the stars are so many and the circles so few. If arrows were to be inserted to show the transformations, they would crisscross into a maze. I have therefore separated the figure into three: all of the circles, stars, and rosettes in it will be found in figure 13 (which is really a pair, as the inscription says) and figure 14.

Taking figure 13 as it stands, we see five of the stars and one rosette of figure 4, connected by arrows: each star marks a nucleus which transforms itself by emission of a particle into the one next following along the arrow-chain. The rosette stands for a stable nucleus, and would be replaced by a circle were it not distinguished by being the terminus of such a chain. These five radioactive isotopes and one terminal nucleus-type belong to the "thorium series," and are known as thorium A, thorium B, thorium C, and so on, according to the letters which adjoin their stars. This is an unlucky bit of terminology, for it suggests that all are isotopes of the same element, which is clearly far from the truth.

Taking figure 13 again and imagining each star moved by one unit to the left (so that e.g., the star A goes to 217), we now are thinking of five more stars and another rosette of figure 4, duly connected by arrows. These constitute (a part of) the "actinium series" and are known as actinium A, actinium B, and so forth.

Taking figure 14 as it stands, we find ourselves confronted by eight more of the stars and the last rosette of figure 4, connected by arrows. These constitute a part of the "radium series" and are known as radium A, radium B, and so on. The "so on" covers more than it did in the other two cases, this chain continuing to the terminus here marked as radium G, though usually known by a different name.

Surveying the scene of these *massive* radioactive nuclei, one is struck by the fact that not all of the arrows are vertical. Many are slanting, and by their slant and their length they show that they represent the emission of alpha particles. It is a feature of some (not of all) of the unstable nuclei of mass-numbers greater than 200, that they strive toward stability by emitting these. For this feature we should be very grateful, since it was by the use of alpha particles from natural radioactive bodies that Rutherford achieved the first of transmutations; though physicists

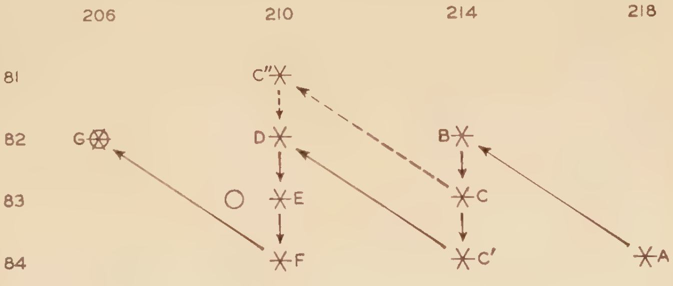

Figure 14. Part of the radium series of radioactive nuclei

now can transmute without their aid, no one can guess how long they would have waited without trying had they not had that encouragement. Vertical arrows also are seen, but again there is a contrast to the lighter isotopes; all of the electrons emitted by radioactive nuclei of mass-numbers beyond 200, or by natural radioactive isotopes of whatever mass, are negative. But for the fact that positive electrons had been observed among the cosmic rays in 1932, they would have been discovered along with the first examples of artificial radioactive isotopes in 1934, and what a sensation that would have been!

More than by anything else, probably, one is impressed by the concatenation of these radioactive nuclei. A long journey to stability lies ahead of thorium A and actinium A, a longer one still ahead of radium A; but the total lengths of the journeys are greater yet, for they begin further back. In figure 15 we behold the three series of radioactive isotopes in their entirety, and it is seen that the three "A-products," as they are called, are midway in the evolution and not at its beginning. The manner of drawing of this figure is changed from the preceding, atomic number being laid off along the horizontal axis and mass-number along the vertical; also, crosses and circles and dots are used to mark the members of the actinium, radium, and thorium series, respectively, and have no bearing on stability or instability. The actinium series should lie lower than it is drawn, with its terminus AcD lying midway between ThD and RaG; the mistake is incurred so as to diminish the overlappings which would otherwise confuse the picture.

Except for a few created in the last three years by transmutation, every known nucleus-type of mass-number greater than 209 and atomic number greater than 83 (as well as a few of slightly lower values) is found in figure 15. It appears that 83 and 209 are critical values of nuclear charge and mass, beyond which the constituents of nuclei —neutrons and protons, presumably, and whatever others there may be—cannot unite into stable systems.* All of these nuclei beyond 209 which are found in nature are seeking for stability by the emission of particles, but never finding it until they have emitted sufficiently many to convert themselves (or rather, the residues of themselves) into one or another of the three isotopes of element 82—*lead*—which are marked by rosettes in figure 4. For an obvious reason these three are called thorium lead, actinium lead, and radium lead. "Ordinary" lead as it comes from most mines is a mixture of many isotopes, but the lead which is found in close association with thorium or with uranium proves its origin from vanished atoms of these metals by being preponderantly the isotope 208 or the isotope 206 as the case may be.

I pause to mention, in justice to Rutherford, that it was he who proved by study of some of these natural radioactive bodies that each is transforming itself into a different element; also it was his associate Soddy who by similar studies was led to distinguish the first-to-be-recognized isotopes, that is, different radioactive forms of one and the same element. The way for making such diagrams as figures 2 and 3 and 4 was prepared before 1910 by these two men, though some of the facts embodied in figure 4 were not then available because of want of knowledge of atomic numbers, and all of the knowledge embodied in figures 2 and 3 was nonexistent because no radioactive isotopes of these elements had yet been created and nobody knew as yet how to distinguish their stable isotopes. Also it should be mentioned that only the extraordinary potency of radioactive substances in affecting our instruments of measure enables the physicist or the chemist to recognize the element to which a radioactive isotope belongs, nay even to detect its presence. With radium and a few others, it has been possible to amass enough of the substance to see and to weigh; with the great majority of natural and with the totality of artificial radioactive isotopes, nothing of the sort has even been approached, and we should still be unacquainted† with them if they had been stable.

Three examples of transmutation which occur in these upper ranges of the periodic table deserve to be recorded in even so brief a report.

In figure 14, notice the circle in row 83 and column 209 which (as I earlier said) represents the highest stable nucleus—bismuth 209. Radium E, represented by the star to its right, is clearly bismuth 210; by the testimony of its mass-number and atomic number, it differs from stable bismuth nuclei by the possession of an extra neutron. If bismuth should be bombarded by neutrons, either free or bound into deuterons, would it be transformed into radium E? Livingood at Berkeley did bombard ordinary bismuth with very energetic deuterons, and did succeed in producing a radioactive substance which agreed with radium E not only in emitting negative electrons, but also in converting itself into a substance emitting alpha particles, and the agreement extended to details of the emission. No doubt exists that he was making radium E out of bismuth 209 by enabling deuterons to transfer their constituent neutrons to this latter, just as H^3 is made from H^2 in the first of the deuteron-deuteron reactions.

In figure 15, notice that all of the members of the thorium series have mass-numbers divisible by 4, or equal to $4n$ with various integer values given to n. This is accordingly called the "$4n$ series," and one readily sees what is meant by calling the radium and the actinium series by the names of "$4n+2$" and "$4n+3$" series, respectively. One begins at once to wonder whether there is not a "$4n+1$" series. Such a series was long sought after in vain, and no member of it has yet been discovered in nature; but in the laboratory of the Curies in Paris thorium has lately been strongly bombarded by neutrons, and a new sequence of radioactive bodies has thus been engendered which has already been followed through several steps, and is in all probability the series so long missing.

As to the remaining feat—the creation of elements beyond uranium—it is now beyond doubt. Fermi and his school at Rome, Hahn and Meitner in Berlin, Curie and Joliot in Paris have all borne witness to it. In one way it seems the most romantic of all the feats of transmutation, for nature had apparently set 92 as the limit of nuclear charge, and now man has transgressed it. The process is begun by exposing uranium to bombardment by streams of neutrons. It appears that when a uranium nucleus has captured a neutron, it finds itself not strongly enough charged to hold together, and proceeds to emit one negative electron after another in its search for stability. Each emission transfers the nucleus to an element one step higher, without affecting its mass-number; and the authorities agree that there are at least four consecutive emissions, after the last of which the atomic number is 96! This addition of four new elements to the periodic table opens a new field to chemists, one which they can scarcely have expected ever to be able to enter. The four have no proper names as yet, a curious circumstance in view of the fact that discoverers of new elements have thus far been in great haste (sometimes too great haste) to name them. Mendeleeff long ago used to denote an expected but undiscovered element by prefixing "eka" to the name of the element just above the vacant place in the periodic table; these new four are sometimes called eka-rhenium, eka-osmium, eka-iridium, and eka-platinum, but on looking at such words one is inclined to prefer the atomic numbers.

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* I recall from an earlier footnote that some of these very heavy nuclei (notably thorium 230 and uranium 238) are so very long-lasting that "unstable," while strictly correct, seems much too strong a word for them.

† This statement should be qualified slightly, for some of the artificial radioactive nuclei spring from reactions of transmutation which are so well understood that the observer could justifiably infer the existence of the nuclei in question even if he did not observe them.

Now to summarize. The world as we knew it before the days of transmutation was constructed out of some 250 kinds of atoms, each consisting of a nucleus surrounded by a family of electrons. Of these 250 kinds of nuclei the great majority were stable and perpetual, but some 40 were unstable—doomed to perish in due time, by ejecting either alpha particles or negative electrons. These were the natural radioactive bodies. To these 40 kinds of radioactive nuclei already found in nature, physicists have added in a scant four years no fewer than 220 new ones by the art of transmutation. Every chemical element which is known to exist at all, with the sole exception of hydrogen, has at least one radioactive type of nucleus or isotope, and many have more than one. These man-made radioactive nuclei are often made simply by adding neutrons to nuclei which already exist and are stable. There are however other and more complicated processes, in which neutrons or protons or deuterons or alpha particles impinge on nuclei and seem to enter them, and other particles leap out. Many radioactive bodies have already been made in two or three different ways, some in as many as five.

Few things are riskier than to suggest a limitation either on the scope of nature or on the possibilities of science, and many a scientist is remembered chiefly for such a suggestion which later the course of events proved foolish. Yet there are circumstances in this case which give some ground for suspecting that already we may know nearly all of the stable and may have created nearly all of the radioactive nucleus-types. Several hundreds of types have now been made by the art of transmutation, but of them nearly all which seem to be stable are not new, and nearly all which are new are radioactive. This implies that the earth has already been stocked with almost all the stable nucleus-varieties, but not necessarily that we have yet come near to making all of the possible radioactive kinds. There are however reasons for believing that most of the remaining types have so little durability, that even if they were to be made they would not last long enough to be identified as radioactive. Nature probably has come quite close to building all the imperishable forms; we possibly almost as close to creating all of those which are capable of a little but not a perpetual life. Perhaps it is fitting that people who are not immortal should not be able to construct new elements which are immortal; but we at least can rejoice in having diversified the scene of the world with a surprising number of new substances which are none the less remarkable for being transitory.

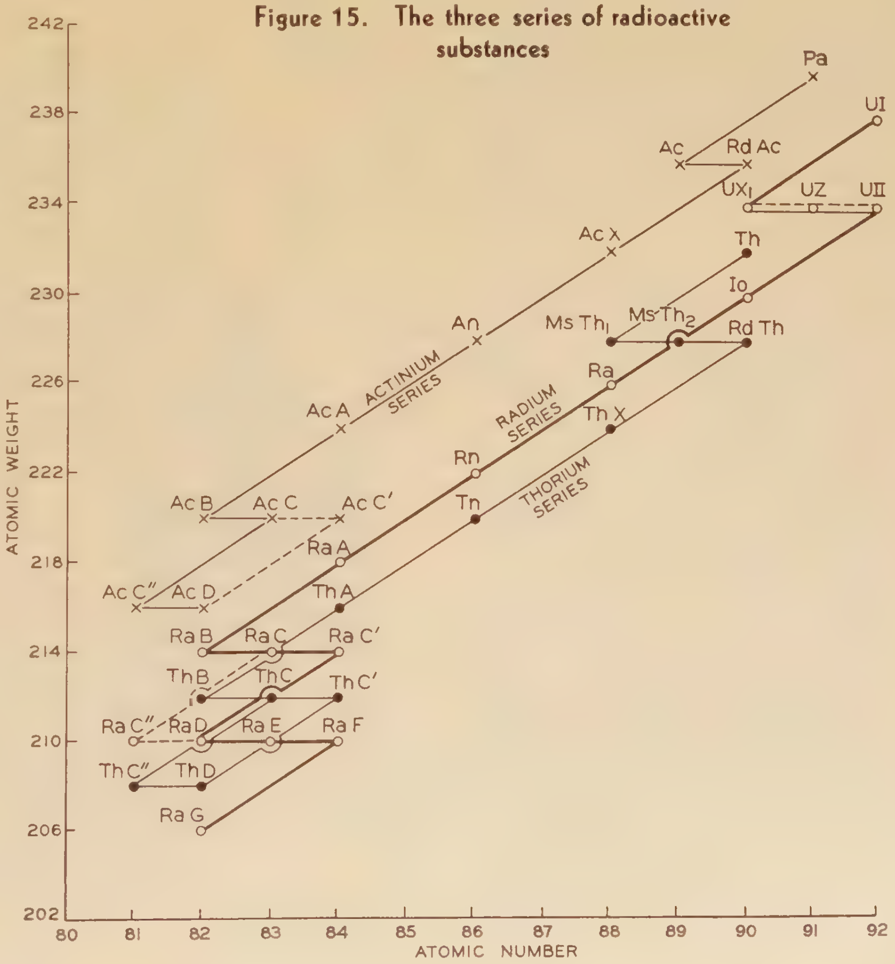
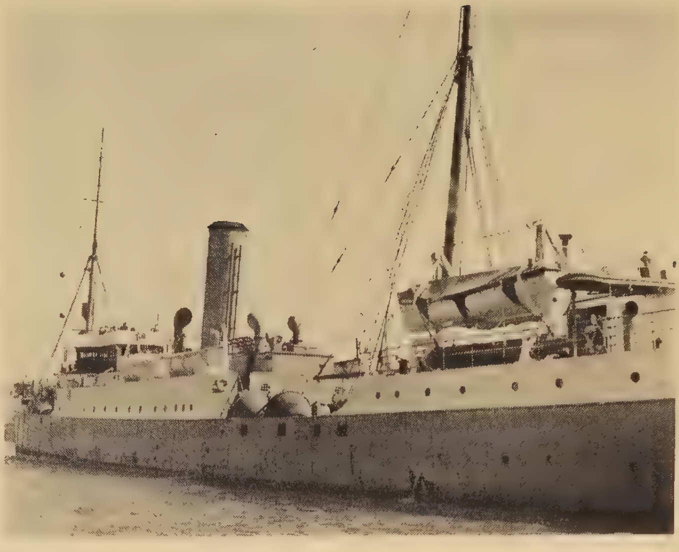


Figure 15. The three series of radioactive substances

Protection of Submarine Cables by Placement "Underground"



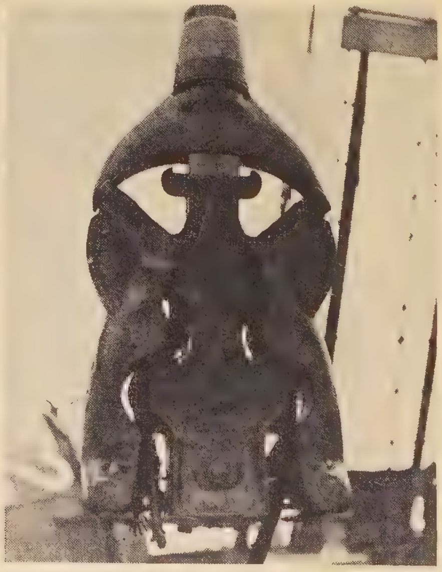
Cable-repair ship "Lord Kelvin"

DAMAGE estimated at $500,000 a year is caused to the transoceanic telegraph cables of the world by the heavy drags or otterboards which are attached to fishing nets dragged along the ocean bottom by steam trawlers. To protect cables in waters where they are exposed to this hazard and thereby reduce this loss, a plow has been devised by engineers of the Western Union Telegraph Company which when pulled along the ocean bottom is expected to cut a furrow, drop the cable into it, and back fill over the cable. The first cables scheduled to be plowed under are in the fishing banks off the coast of Ireland, where damage is particularly severe.

One of the major necessities for this work was a tow line capable of withstanding a 65,000-pound stress, and flexible enough to permit its management by equipment on the ship. Early experiments showed that wire rope developed torque when under strain and was too stiff for easy handling, and that only a chain was practicable for this purpose. Therefore a continuous length of 4,200 feet of nickel-steel chain was obtained. Reputedly the longest chain ever manufactured in one piece, it comprises 12,500 links, and weighs 43,000 pounds. The chain recently was loaded on the *Lord Kelvin*, flagship of the Western Union cable-repair fleet, during its first visit to New York Harbor since its construction in 1916; at this time the photographs reproduced in the accompanying illustrations were obtained.

The *Lord Kelvin* is a 332-foot oil-burning ship with a loaded displacement of 5,500 tons, and carries a complement of 85 men. In addition to machinery for paying out and picking up cable, other special equipment for repair work is provided, including testing equipment for determining the location of cable faults Two general types of grapnels for raising cables are carried; one type hooks the cable, and the other hooks and cuts the cable and brings up only one end, since cables in deep water have insufficient slack to permit a loop to be brought to the surface. Four cable tanks provide capacity for several hundred miles of cable, of which several types are required in order that any type in use may be replaced. Navigational aids include depth and range finders.

Loading the specially designed 4,200-foot nickel-steel chain that is to be used for plowing operations



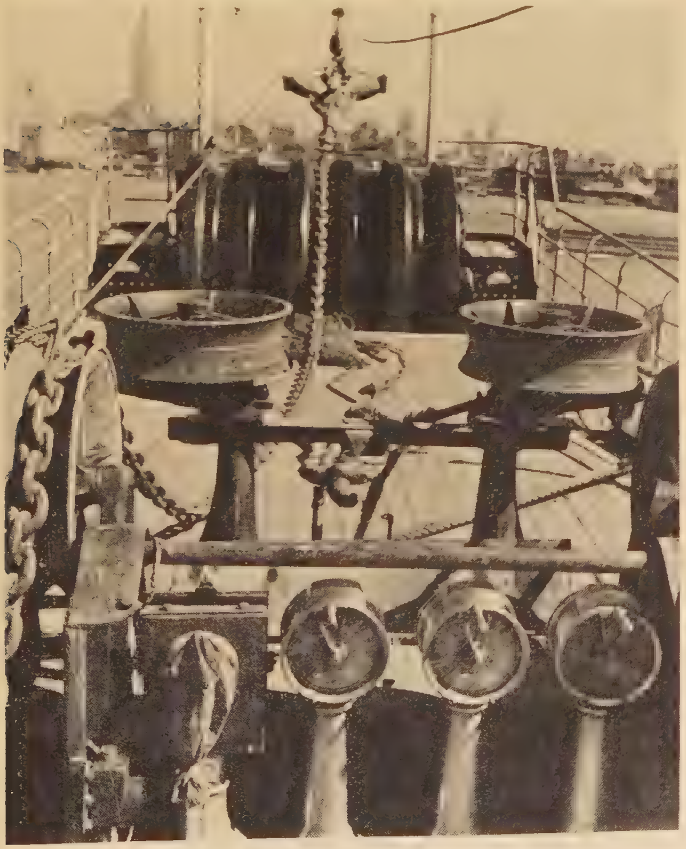
A cutting grapnel by means of which cable is picked up from the bottom of the sea

Cable marker buoys; largest weighs one and one-half tons and can support a safe load of four tons

Cables may be damaged by a variety of causes, ranging from icebergs to marine borers. When a break occurs in a cable, the position of the rupture may be determined by measurements of the electrical resistance of the conductors; records show that more than 50 per cent of the positions may be determined within 0.5 nautical mile. The route of the cable being known from astronomical observations which are taken continuously during the laying of all cables, the latitude and longitude of the position where the cable is broken are obtained. Upon reaching this location, the repair ship moors a mark buoy as nearly as possible over the position of the cable, and passes and repasses at a speed of about one mile per hour at right angles to the line of the cable until the cable is hooked.

Splicing a broken cable is the most delicate operation aboard a cable ship. After joining the conductors of the two cables to be spliced, they are wrapped with successive layers of fine copper wire. Each layer of wire is soldered, after which the conductor is sheathed in gutta percha. In the tropics a hose is played on the cable to prevent the gutta percha from softening and permitting the conductor to become decentralized in the gutta percha; the cable carried by the ship in the cable tanks is kept under water in warm climates for the same reason. Moisture, however, must be kept out of the splice; trouble may be caused even by perspiration from the splicer's hands.

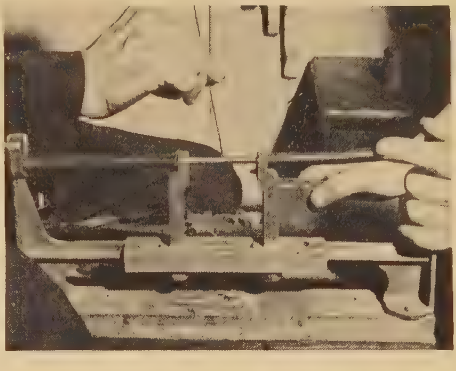
Cable that has been plowed into the ocean bottom will require a different technique for locating and grappling. This problem is being given careful study.



Foredeck of the "Lord Kelvin" showing cable bow sheaves and deep-sea cutting grapnel

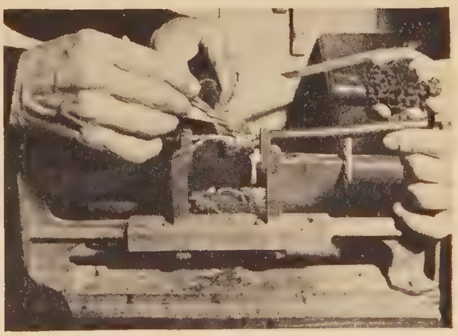
The only tent at sea is erected aboard cable ships for the delicate work of splicing cables

After joining the conductors, successive layers of fine copper wire are applied

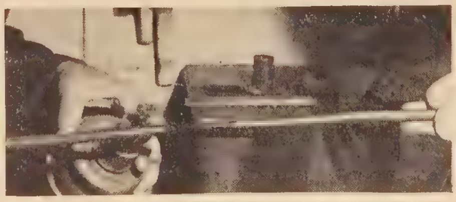


Each successive layer of wire is soldered; here the joint is being heated by a spirit lamp

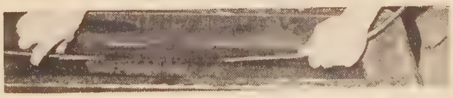
Soldering a splice



Covering a splice with gutta percha



Testing a cable splice



Some of the steps necessary in splicing cables

The Young Engineer's First Years in Industry

By **FRANK L. EIDMANN**
Member ASME

Personal merit long has been recognized as the most important factor in the selection of people for unusual opportunities. Personal opinion may vary widely as to where responsibility for development lies, but no young engineer can do better than to assume it himself. The suggestions summarized at the end of this article are logical conclusions based on careful study and rationalization of opinions of people sympathetic to problems of adjustment. They should be of interest to every graduate.

HOW WELL satisfied are industrial executives with the young engineering graduates whom they employ? In visiting a large number of industrial plants over a period of years I have raised this question. Recently, I also sent a questionnaire on this subject to executives of 60 well-known manufacturing companies in many lines of industry, such as machine tools, locomotives, paper, steam turbines, electrical equipment, brass and copper, Diesel engines, automobiles, cameras, power-plant equipment, abrasives, steel, chemicals, watches, clocks, heating and ventilating equipment, shoe machinery, packaging machinery, drive chains, cash registers, ball bearings, instruments, typewriters, taps and dies, elevators, and special machinery, and also to public utilities, consulting engineers, and railroads. Replies were received from nearly all. In answer to the question, "How many of these young engineers turn out to be satisfactory?", the largest number of replies gave estimates of between 50 and 90 per cent. A few stated that only ten per cent prove satisfactory, and two companies are satisfied with all of the young engineering graduates whom they hire.

How about the young engineers who do not prove satisfactory? What is wrong with them? The answers indicate almost unanimously that personal traits and attitude rather than lack of technical training or ability are responsible. The principal fault seems to be the "inability to get along with their associates," or the "lack of ability to fit in quickly with their fellow employees and to make friends readily." The criticism mentioned in the next largest number of replies is "overeagerness for advancement." Other criticisms are: "Unwillingness to prepare for advancement over a long enough period," "lack of aptitude for engineering work," "inability to adapt themselves to the routine of operating work and at the same time avoid getting into a rut," "lack of initative," "inability to grasp the practical aspects of problems and situations," "impractical and unable to apply themselves," and "lack of willingness to work."

You would be justified in asking just what is meant by the term "unsatisfactory" as used in this article. Some of the executives made this clear by stating that probably 70 to 90 per cent of the young men turn out to be reliable routine workers, and, so long as their work does not fall below a reasonably exacting standard, they are retained. Only a small percentage of the men, however, turn out to be satisfactory in the sense of measuring up to expectations. Industry expects that, after a reasonable period of orientation, these young engineers will accept responsibility, show initiative and enthusiasm, and make more rapid progress than young men without college training who have come up through the shop positions.

It is to be emphasized that most of the executives, with whom I conferred or who responded to my questionnaire, show a keen and sympathetic interest in young college-trained engineers and offer their comments and criticism in a friendly spirit and with the hope of being helpful. They recognize the need of these young men as recruits in their organizations and would like to employ more of them than they do at present. Although some executives have become so discouraged in their experiences with young college men that they have definitely decided not to hire them until they have had a few years of experience with other companies, most industrial executives still believe that these young men, carefully selected, are the best source of potential leaders for the future.

Who Is to Blame for Failures?

In some of my interviews with executives, I raised the question concerning the responsibility for such a large percentage of the young engineers turning out to be disappointments to their employers. I asked whether the colleges are to blame, whether the trouble lies with the young men, or whether the employers are largely responsible. As previously mentioned, industry attributes most of the difficulty to the personal traits and attitude of the young engineers. A few employers place part of the blame on the colleges. None of them has suggested that he, himself, might be responsible. From my observations, I have come to the conclusion that the responsibility for the low percentage of young engineers who make good in industry lies in all three directions, that is, the young man,

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Essential substance of an address scheduled for presentation at a meeting to be held under the auspices of the junior group of the metropolitan section of The American Society of Mechanical Engineers, New York, N. Y., May 12, 1938. Published also in the May issue of *Mechanical Engineering* under the title "The Engineering Graduate's First Years in Industry," and made available here through the courtesy of George A. Stetson, editor of that publication.

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the college, and industry. It is apparent, also, that considerable misunderstanding frequently exists on the part of all three. Some of the young men have false notions as to their importance, the rate at which they should be advanced, and the value and importance of practical experience gained over a period of years by men who may lack college education. The colleges may fail to recognize the difficulty of the raw graduate to adapt himself to industrial life; may fail to inform the student as to the requirements of industry, the rate of advancement that may normally be expected, and the value of a college diploma; and the methods of selecting students may be poor, with the result that some young men do not know until after their graduation from college that they have not the aptitude for engineering work in industry. Some employers take it for granted that the college-trained engineer is trained in detail for industry and are disappointed when they find that this is not so. They fail to provide training and supervision that are essential for these young men during the period of readjustment from college to industrial life.

It is unfortunately true that many college-trained engineers fail to attain more than mediocrity in industry. But similarly in all professions, lines of work, and walks of life, the percentage of individuals who are outstandingly successful is indeed low. In fact, my observations convince me that the engineer's record compares favorably with that of other professions.

For engineers as well as for individuals in practically all other lines of endeavor, the leading hinderances to success are due to personal traits rather than to the lack of technical ability. Recently the American Banking Institute made public the results of an investigation of the causes of discharge of 4,000 office employees of 76 important firms. The survey showed that only ten per cent of those discharged lost their positions because of lack of ability to do their work. The other 90 per cent were discharged for reasons of a nature personal to the employees, such as carelessness, laziness, lack of co-operation, dishonesty, and lack of initiative.

Where the Young Engineer Is at Fault

It is true that many college-trained engineers are impatient for advancement, many have exaggerated ideas as to their worth to the company, and some take a superior attitude toward their fellow workers who have not attended college. These ideas and attitudes are, of course, not confined to engineers. The high-pressure recruiting methods that are followed by some firms are partly responsible for the student's mistaken ideas of his importance. Personnel officers start coming to the colleges as early as November to interview seniors, and some firms make tentative selection of the engineers fully two years before they graduate. In spite of the prevailing business conditions, all of the mechanical-engineering students who graduated from Columbia University last June had definitely accepted positions before the preceding February. Some had as many as three offers from which to choose. One student had been selected two years previous to his graduation. Part of the responsibility for the false notions of importance, therefore, clearly rests upon industry. College faculties must also share this responsibility when they allow these young men to go out into industry with mistaken notions. Students should be informed that recognition in industry comes only as the result of accomplishment which is achieved by long hours of hard work. Every student should also understand that the bare fact that he graduated from college entitles him to nothing, but that it will give him a tremendous advantage over his noncollege associates in opportunity to forge ahead. It should be pointed out to the student that, while he has been spending years in college, other keen, capable young men of his age have been receiving a practical training in industry, have become well acquainted and firmly entrenched in the organization, and have probably done considerable reading and studying. Not only must the college-trained man compete with these men who have a practical training, but he also has to make the sudden and severe adjustment from campus to commercial life. Perhaps he may even have an attack of homesickness. This is, therefore, a critical period in his career and many times does he become discouraged with his progress, especially when he hears of classmates and other friends who may be progressing more rapidly.

Before he leaves college, the young man's attention should be called to the complaint so often heard as to the superior attitude of college graduates toward noncollege men in industry. Although some college graduates do make this mistake, I have found that it is a matter of imagination on the part of many noncollege men. Nevertheless, the college man must be careful to avoid giving this impression. The matter of impatience for rapid advancement will take care of itself if the college and the employer will make it plain to the young man that it takes time and effort for the raw graduate to orient himself to the new work and that he must prepare himself and show himself ready for advancement. The company, especially, can do much to prevent misunderstanding by letting the young engineer know what progress he can normally expect to make if his services are satisfactory. It also should closely observe and supervise the young man in his work and relations with fellow employees and inform him, from time to time, whether his progress is satisfactory and in what way he is considered weak.

Lack of aptitude for engineering work is one of the reasons given for disappointment in the progress of young engineering graduates. We are also told that many students in engineering schools are not properly qualified and do not have the proper aptitude for engineering. Both statements are unfortunately true and are sad reflections on the selection by engineering schools and by industry. I look for the day when *engineering-aptitude* tests both by engineering schools and by industry will become important factors in selection of young engineers. Let me emphasize that I mean engineering-aptitude tests and not the usual intelligence, psychological, and achievement tests.

It is significant that so many firms find that students who have spent their summers working in industry, and students of co-operative engineering courses become so much more quickly adjusted to their work after graduation and that failures among these men are fewer. These students naturally know what to expect when they enter industry and they know also, whether or not they are suited for this kind of work.

Industry's Responsibility

Many firms operate so-called training courses or programs for engineering graduates. Most of these consist essentially of having the young graduate serve for a short period in each of the departments of the plant. Unfortunately in most cases, the young man is allowed to shift for himself during this period, without encouragement, guidance, supervision, or training. He is compelled to pick up what information he can in a hit-or-miss way. As a consequence, many graduates flounder hopelessly for several years during this early period in industry, which is probably the most important in their industrial career. It is during this critical period that the severe adjustment from campus to commercial life must be made. New friendships have to be formed, and the young man is thrown on his own resources usually for the first time in his life. A carefully planned program under guidance and supervision shortens considerably the time required for training and personal adjustment, better prepares the young engineer for his work with the company, and greatly decreases the number of cases of dissatisfaction. I know of instances in which engineering graduates were discouraged and underpaid, their ability was unappreciated, and they made little progress under their first employer. These same men responded quickly and made more than average progress under their second employer, who offered guidance, encouragement, and instruction.

When hiring a college graduate, I think the company should make it plain that no assurance is given of a responsible position, progress will depend entirely upon accomplishment and attitude, and the college degree does not bear as much weight as the young man probably thinks it does. The young graduate should also be given an idea as to what progress he can normally expect to make if his services are satisfactory. Many students seem to have a wrong idea of what to expect.

Compensation is an important matter. The salary scale should be a fair one and provide for periodic increases. Some companies pay the beginner $175 or more per month, while I know of others that pay as low as $16 per week. It is certainly difficult for an employee of the latter to be contented and enthusiastic and to do his best work when he knows that his classmate is making a higher salary.

Advice to the Young Engineer

Some of the criticisms from industry regarding college-trained engineers have been mentioned. The young graduate should study them with profit. The following summary may be of help:

1. Make a special effort to fit in quickly with your fellow workers, remembering that industry places more importance on the ability to get along with fellow employees than it does on technical knowledge and ability.

2. Be ambitious, but do not expect rapid promotion to supervisory positions.

3. Determine whether or not you really have the aptitude for engineering work in industry. If you do not have it, you will probable be happier and make better progress if you are transferred to some other kind of work. An engineering training is a good background for work in many lines.

4. Cultivate the ability to adapt yourself to the routine of operating work without getting into a rut.

5. Show willingness to prepare yourself for advancement, by continued study and reading and by familiarizing yourself with all phases of your company's business.

6. If your company offers the opportunity of working for a period in each of the operating departments as well as in the engineering department, by all means give it your consideration. This method is one of the best to learn the details of a business and to become acquainted in the organization. But bear in mind that how much you will learn is entirely up to you. It will be well for you to outline systematically what information to look for in each department. Keep notes and study them. Study the product of competitors.

7. Do not overestimate the value of your college degree, for it entitles you to nothing. Recognition in industry comes only as a result of accomplishment which is achieved by long hours of hard work. But your college training should give you a tremendous advantage in opportunity to forge ahead.

8. Cultivate the ability to grasp the practical aspects of problems and situations.

9. Cultivate a cost-minded attitude toward all problems that arise in the course of your work. Before making a recommendation, analyze it from the viewpoint of "Will it pay?"

10. Practice report writing. Employers mention a general weakness of young engineers to express themselves effectively orally or in writing.

11. Show enthusiasm and a willingness to work. Be willing to accept responsibility.

12. Cultivate initiative, restrained by reason. Offer to do things without being told. Study processes, machinery, equipment, and product with a view of suggesting improvements, but be careful, in submitting your suggestions, not to raise antagonism.

13. Do not get discouraged.

14. Endeavor to find out from time to time whether your progress is satisfactory to your employer. Invite suggestions as to your weaknesses, so that you can try to improve.

15. Broaden your interests outside of engineering. Although only about 15 per cent of the employers whom I have consulted stress the importance of nonengineering subjects when hiring young engineers, more than 50 per cent of all who answered the questionnaire believe that these subjects are essential to the success of any graduate and will help materially in making progress.

16. Join a professional engineering society; attend its meetings; read its publications. Read technical and trade journals in your line.

Westinghouse Photo

Some Electronic Switching Circuits

By C. C. SHUMARD
MEMBER AIEE

SWITCHING usually is considered as the physical opening or closing of metallic circuits as, for example, where a circuit breaker or a knife switch is put in motion mechanically to break or make connections between conductors leading to a circuit or device. However, switching may be performed in other ways, as by changing the operating potentials from one polarity or magnitude to another polarity or another magnitude. For example, a control voltage on an amplifier tube may be altered to change the circuit from a nonamplifying to an amplifying condition. The making of circuits operative or inoperative by a change in polarity or magnitude, or both, as performed by means of an electronic device is called "electronic switching." No moving parts are involved and the control may be much faster and more economical than control by mechanically operated devices. If two circuits or devices are controlled by an electronic switch, it is called a two-circuit electronic switch.[1,2] In the same way, if three, four, or five circuits are controlled, the electronic switch is called a three-, four-, or five-circuit electronic switch.

Basic Switching Circuits

Although several different types of electronic switches have been devised, this discussion is confined to the type that is considered to be most flexible in its operation. It may control a large number of circuits and, for this reason is called an "*n*-circuit type." The basic circuit of this type of switch employs type-885 gaseous triodes arranged symmetrically so that each tube is made to conduct in a definite order, and in so doing to deionize or stop conduction of the previous tube.[3] As each tube conducts, a voltage drop is produced across a resistor placed in series with the cathode of the tube. This voltage appearing in sequence across each cathode resistor is then, in effect, a switched voltage.

The primary purpose in the derivation of this type of switching circuit was to provide for the observation of several recurrent patterns or wave forms simultaneously on a cathode-ray-tube screen. For this purpose, a suitable amplifying tube is associated with each type-885 tube. Each amplifier tube is controlled by the switched voltage of its gaseous triode and thus is made to operate in sequence with the other amplifier tubes. Although separate input signals are applied to the amplifier tubes, their output currents produce voltage drops consecutively across a load resistor common to all amplifier tubes. The deflecting plates of a cathode-ray tube are connected across the common load resistor and are supplied thus with separate, consecutive voltages from each of the amplifier tubes. In this way, the forms of the voltages supplied to the input circuits of the amplifier tubes can be made to appear apparently simultaneously on the cathode-ray-tube screen. This application, as well as other applications, is discussed after the design factors of the basic voltage-switching circuit have been considered.

Priming

One important requirement for the basic voltage-switching circuit is that to each type-885 tube must be applied a suitable grid-bias voltage, which will determine the specific function of the tube at any particular time as a voltage is switched from one cathode resistor to another. Since symmetrical circuits are used, a description of the cycle of events may be made complete by starting with the steady-state conduction period for one tube and ending

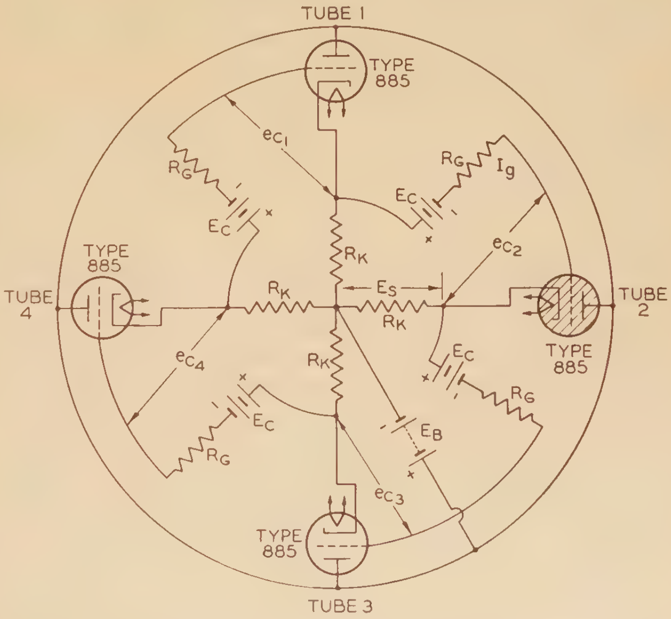

Figure 1. Symmetrical grid-biasing system as used in a four-circuit electronic switch

$e_{C1} = E_c + I_g R_{K1}$ for an unprimed tube
$e_{C2} =$ 0 volts approximately for conducting tube
$e_{C3} = E_c + E_s$ for primed tube
$e_{C4} = +E_c$ for an unprimed nonadjacent tube
Tube 2 conducting

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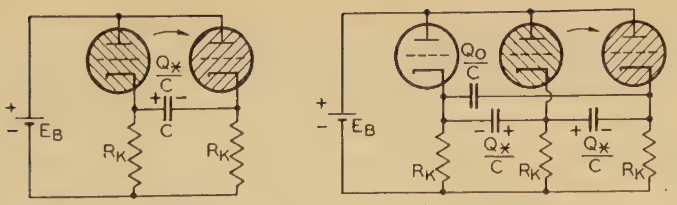
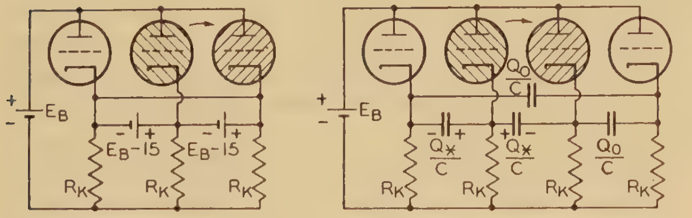
The author wishes to thank P. A. Richards for his co-operation, particularly in obtaining the photographs included, and to give acknowledgment to F. H. Shepard, Jr., for the use of his common grid-biasing system which was modified by the author to decrease appreciably the effective switching time.

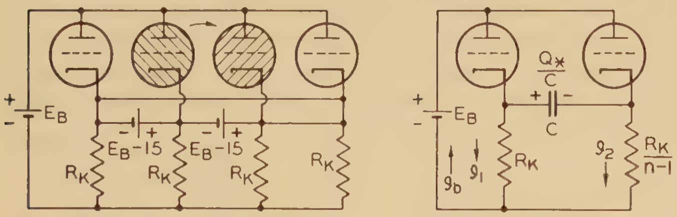
1. For all numbered references, see list at end of paper.



(a) TWO TUBES (b) THREE TUBES



(c) EQUIVALENT OF (b) (d) FOUR TUBES



(e) EQUIVALENT OF (d) (f) EQUIVALENT FOR n TUBES n>1

$\frac{Q_*}{C} = E_B - 15$ $\frac{Q_0}{C} = 0$

Figure 2. Typical shutoff circuits using two or more tubes

$$\frac{Q_*}{C} = E_B - 15 \qquad \frac{Q_0}{C} = 0$$

Approximate peak currents for diagram *(f)* after shutoff

$$\mathfrak{i}_1 = \frac{2(E_B - 15)}{R_K} \tag{1}$$

$$\mathfrak{i}_2 = \frac{(n-1)(E_B - 15)}{R_K} \tag{2}$$

$$\mathfrak{i}_b = \frac{(n+1)(E_B - 15)}{R_K} \tag{3}$$

with a similar steady-state conduction period for the tube next in order. Figure 1 shows a symmetrical biasing system for four type-885 tubes as used in a four-circuit electronic switch. This circuit illustrates biasing conditions only. When no tube is conducting, each tube has a grid-bias voltage E_c and a common anode-supply voltage E_B.

If one type-885 tube, say tube 2, is made to conduct by reducing its bias voltage to less than the breakdown value momentarily, the voltage across the cathode resistor R_{K2} of that tube suddenly will become about $E_B - 15$ volts. This voltage, if the anode-supply voltage is constant, will be of substantially constant value, since the drop in a type-885 tube is substantially constant. The voltage $E_B - 15$ constitutes the switched voltage and is designated E_s. Because the voltage E_s is produced in R_{K2}, the bias voltage on tube 3 becomes $E_c - E_s$. The bias voltages on tubes 4 and 1 remain unchanged, if the resistance R_G is high compared with the resistance R_K, so that the grid current of tube 2 causes negligible voltage drop across R_{K1}. But the grid-bias voltage of tube 3 will be reduced by the magnitude E_s so that the tube will be nearer to the conducting point. Conduction by one tube thus preselects the next tube which is to conduct. This process is called *priming* and the tube so preselected is called a *primed* tube. The other nonconducting tubes are designated *unprimed* tubes. If now a positive impulse voltage of magnitude greater than the difference between the priming bias and the breakdown bias on primed tube 3, but less than the difference between the actual bias and the breakdown bias on tubes 4 and 1, is applied simultaneously to the grids of all type-885 tubes, the primed tube 3 will conduct, while tubes 1 and 4 will not.

A method of biasing all type-885 tubes from a common voltage supply and obtaining priming in a similar manner is discussed later.

SHUTOFF

When the primed tube is caused to conduct, the previously conducting tube should be shut off simultaneously. In figure 2*a* is shown an elementary shutoff circuit for a two-tube switching circuit in which the cathodes of the two tubes are coupled by the capacitor *C*. Since shutoff can be made practically independent of the grid-bias voltages once they are properly adjusted, the grid connections are not shown on the circuit. Tube 1 is shown conducting and tube 2 is primed. Before tube 2 is caused to conduct, a steady-state voltage E_s is established across the capacitor *C*. Tube 2 now may be made to conduct in a very short time compared with the time constant of any external switching circuit that can be employed practically. Capacitor *C*, however, begins to discharge through the cathode resistor R_K and the two conducting tubes, as soon as tube 2 starts to conduct. As the voltage across R_K and the reverse current through tube 1 increase sufficiently, tube 1 is deionized. If shutoff is assumed to occur instantaneously, two, three, four, or more circuits reduce momentarily to the circuit of figure 2*f* and the peak currents are as shown. For example, the maximum peak current to be supplied by the newly conducting tube is the number of tube circuits plus one, times the steady-state current. This equation is important because the type-885 tube should not be allowed to exceed its peak-current rating.

Shutoff does not occur instantaneously; the smaller the time constants of the cathode coupling circuit, the more capacitor *C* is discharged before shutoff is effective. These factors limit the maximum number of switching operations per second that may be performed for an allowable switching interval.

Figure 3 shows the calculated transient voltages produced in the cathode resistors of each tube after shutoff of tube 2 for a four-circuit switch. In these calculations it has been assumed that the charges on the capacitors adjacent to the tube to be shut off are not appreciably dissipated before shutoff is complete. These voltages are designated by e_{K1}, e_{K2}, and so on. The voltage across the cathode resistor of tube 3 is the switched voltage E_s, here equal to 100 volts. The ratio of the maximum peak currents to the steady value is five, since $n = 4$. All voltages vary with time as the algebraic sum of exponential voltages except the switched voltage, which is substantially constant. For these curves $C = 0.002$ microfarad and $R_K = 5{,}000$ ohms.

Figure 4 shows oscillograms of the superimposed transient voltages e_K occurring respectively across the cathode resistors of two-, three-, and four-circuit electronic switches for a switching or impulse frequency of 5,000 cycles per second. The horizontal sweep frequency also is 5,000 cycles per second. The values of $C = 0.002$ microfarad, $R_K = 5{,}000$ ohms, and $E_s = 100$ volts are the same as for figure 5, which shows similar transient voltages for a seven-circuit switch. In figure 5*a* the transients are superimposed, but in figure 5*b*, they are shown in consecutive order. The horizontal sweep frequency in figure 5*b* is one-seventh of the switching or impulse frequency in figure 5*a*.

A comparison of actual and calculated transient values of e_K shows a reasonably close correspondence for these C and R_K values, which are fairly low. Evidently the correspondence is least for the condition $n = 2$, where the actual time constant is lowest and the loss of capacitor charge greatest. The actual initial values, as would be expected, are not as high as the calculated values indicate, but the full maxima do not appear on the photographs, partly because some time is required for the sweep return.

All transient curves show that the switched voltage E_s is substantially constant but that the transient voltages e_K decrease to zero at different rates. For each value of n the voltage e_K of the longest positive duration is the one for the tube which has just been shut off. A rise of about 20 per cent in effective plate voltage may occur on the second tube preceding the conducting tube for values of n greater than two.

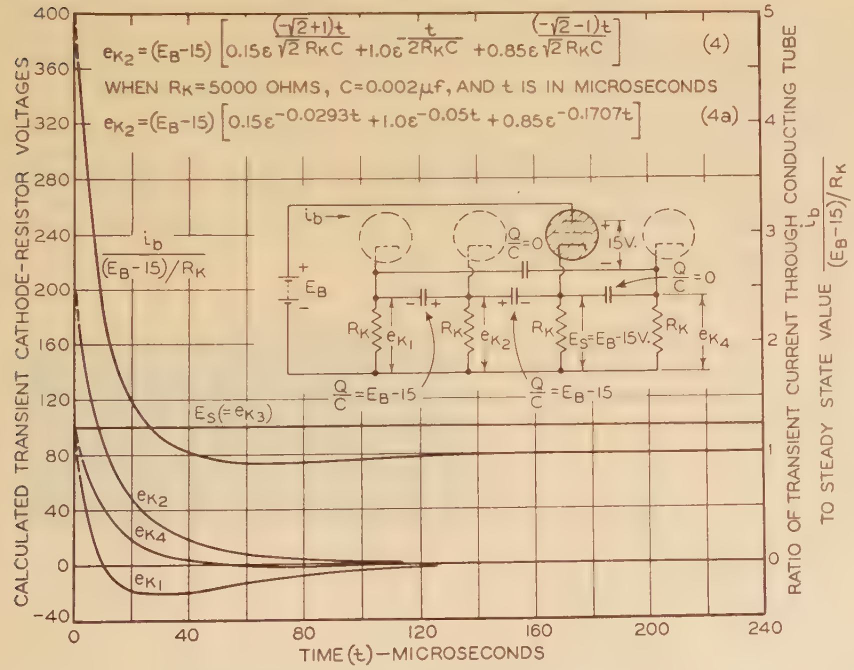


Figure 3. Curves of calculated transient voltages produced in the cathode resistors of each tube after shutoff of tube 2 for a four-circuit switch

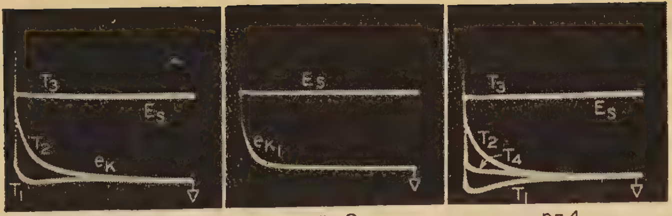
IMPULSE VOLTAGE CONSIDERATIONS FOR TRIGGERING

The character of the impulse voltage required to break down or trigger consecutively each tube of the basic voltage-switching circuit also requires consideration. The impulse voltage should be of steep wave front; a voltage of sinusoidal wave form is not suitable. The impulse voltage across the series plate resistance R_t of the usual sweep circuit at the time of discharge of the sweep-circuit capacitor generally has been found to serve satisfactorily. Such a voltage is of approximately exponential form. Some slight modifications of the sweep circuit ordinarily are necessary because the impulse voltage should be positive with respect to ground. Figures 6 and 7 show the essentials of the usual sweep circuits employing a current-limiting tube and current-limiting resistance, respectively. Figures 6*a* and 7*a* show the modifications necessary for using these circuits as positive-impulse sources.

The ordinary sweep-discharge voltage e_t obtained by connecting across the relatively low impedance R_t, usually is of sufficient amplitude, is synchronized with the sweep automatically, is of very short duration, and may be synchronized readily to a suitable reference voltage. The value of R_t usually is fixed at some value of from 500 to 1,000 ohms. This resistor may be used as a potentiometer for adjustment of the impulse voltage, or an auxiliary voltage divider may be employed. If the latter is used, its resistance should be kept low to avoid impulse attenuation, particularly at high switching frequencies. Its resistance, however, should not be low enough to reduce the effective value of R_t much below 500 ohms.

The amplitude of the impulse voltage e_t is only slightly less than the sweep-capacitor voltage at sweep-tube breakdown less the tube voltage drop of approximately 15. At low values of switching frequency F_t, e_t usually is of ample magnitude. At high values of F_t the attenuation of the impulse voltage attributable to circuit and grid capacitances may be great enough to prevent the application of sufficient triggering voltage to the grids of the type-885 switching tubes.

The duration of the impulse depends essentially on the time constants R_t C_s of the sweep-discharge circuit, where C_s is the selected value of the sweep capacitors C_{s1}, C_{s2}, etcetera. The time constant R_t C_s therefore is altered if the value of C_s or R_t is changed. Such changes usually are made to obtain the desired sweep-frequency ranges and the values of C_s ordinarily range from 1.0 microfarad to 0.0005 microfarad. This gives an R_t C_s range from 500 microseconds to 0.25 microsecond for an R_t value of 500 ohms. The value of R_t C_s should not be large compared with the time constants of some of the switching circuits as explained later. However, the R_t C_s range ordinarily used is satisfactory.



n=3 n=2 n=4

Figure 4. Oscillograms of superimposed transient voltages across the cathode resistors of two-, three-, and four-circuit electronic switches for an impulse frequency of 5,000 cycles per second

C = 0.002 microfarad, R_K = 5,000 ohms, E_s = 100 volts, F_i = 5,000 cycles per second

R_1 = 100,000 ohms
R_2 = 50,000 ohms
R_g = 150,000 ohms
R_j = 30,000 ohms

E_B = 115 volts
E_C = −105 volts
$e_{i\,\min}$ = 50 peak volts
c_i = 100 micromicrofarads

If modification of the auxiliary sweep is desirable, a second simple sweep circuit may be constructed to meet the requirements, and may be made a part of the switch circuit itself. Thus, since linearity is no object, suitable circuit constants may be chosen and higher impulse output may be obtained by increasing the bias voltage on the second auxiliary sweep tube. This sweep voltage is synchronized to the same reference voltage as the usual sweep voltage so that the two return times coincide.

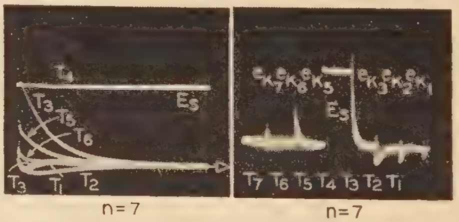
The use of the impulse voltage is closely related to the method of obtaining the grid bias for the type-885 tubes. Since a common voltage supply for the grid bias generally is used, it is considered desirable to describe first this biasing method and then show how the impulse voltage is applied.

GRID BIASING FROM A COMMON VOLTAGE SUPPLY

Separate grid bias may be used, as shown for illustration purposes in figure 1, but common grid bias requires only one source of bias voltage, which can be grounded. This common grid-biasing method is shown in figure 8*a* where the grid bias is applied to the grid of each type-885 tube by means of the voltage-divider circuits R_K, R_1, and R_2 from the bias-supply voltage E_c. From the transient standpoint, it will be usually desirable to keep the values of $R_K C$, and hence R_K, small but R_1 and R_2 may or may not be large compared with R_K depending on whether or not it is desired to have a substantial negative voltage from cathode to ground for a nonconducting tube. A negative voltage may be desirable (as shown later) because it reduces the effective transient times of switching. For this reason, it is preferable to compute the general bias conditions; from these, the conditions for which R_1 and R_2 are large compared to R_k may be obtained easily. For the steady-state condition with one tube, say tube 2, conducting, the resistance network for the bias voltages of four or n tubes becomes a simple equivalent network as progressively shown in figure 8. The resistance $R_G = R_g + R_j$ is made large compared with R_K in order to limit grid current to a small value relative to the plate current, so that the drop through the cathode resistor of tube 1 caused by the grid current of tube 2 may be assumed to be negligible. Because the grid potential of a conducting tube is very closely the same as its cathode potential, the grid of this tube is shown connected to its cathode. The grid bias on the primed tube is indicated as e_c'; all other tubes, being unprimed tubes, have the bias shown as e_c. As stated previously, the capacitors C_i shown in figure 8*a* are used for impulse coupling.

In figure 9 are shown the current and voltage relations for the general case, with R_1 and R_2 of the same order as R_K, and for the special case in which R_K may be neglected in comparison with R_1 and R_2. Again, of course, e_c is the bias on unprimed tubes and e_c' the bias on the primed tube; e_d is the difference in bias between unprimed tubes and the primed tube. These voltages may then be computed in terms of the desired switched voltage E_s from a consideration of normal breakdown grid voltages and the transient voltages.

Figure 10 illustrates the selection of the operating voltages. Here the voltages e_c, e_c', and e_d are plotted in terms of E_s, the desired switched voltage, for a ratio of $R_1 = 2\,R_2$, or $a = 2$, where R_1 and R_2 are assumed to be large compared with R_K. The line e_c'' gives the approximate grid-bias voltage at which any nonconducting type-885 tube will become conducting. This voltage is equal to the plate voltage divided by the grid-control factor E_B/μ, or in terms of the switched voltage E_s and grid-control factor of ten, $e_c'' = (E_s + 15)/10$ volts. The lines marked E_c = 180, 165, etcetera, terminating on the breakdown voltage line, provide data for the determination of the bias voltages on the primed and unprimed tubes. For example, suppose the switched voltage desired is 100 volts. Then the breakdown voltage is (100 + 15)/10 or 11.5 volts. The E_c grid-bias line that just gives this value is the one on which E_c is 67.5 volts. However, the reader will recall that a rise in plate voltage of about 20 per cent of E_s may be obtained from the transient voltage rise across the R_K of the second tube preceding the conducting tube if n is greater than two. This rise requires an increase of two volts in the grid bias for the unprimed tubes. Moreover, noncritical impulse-voltage control is desired. If the grid-bias voltage on a primed tube is established at 20 volts from breakdown, a critical impulse-voltage control and sufficient allowance for the transient voltage rise



n=7
(a)

n=7
(b)

Figure 5. Oscillograms of transient voltages for a seven-circuit switch

C = 0.002 microfarad, R_K = 5,000 ohms, E_s = 100 volts, F_i = 5,000 cycles per second

R_1 = 100,000 ohms
R_2 = 50,000 ohms
R_g = 150,000 ohms
R_j = 30,000 ohms

E_B = 115 volts
E_C = −105 volts
$e_{i\,\min}$ = 50 peak volts
c_i = 100 micromicrofarads

are provided. The values of grid-bias voltage for primed tubes given by the line 20 volts from breakdown ordinarily will be feasible for intermediate values of desired switched voltages around 100 volts. The intersection of the ordinate at $E_s = 100$ volts and the line $e_c' = (20 + e_c'')$ volts gives an E_c of about 96 volts, an unprimed-tube grid bias of 64 volts, and a primed-tube bias of 32 volts. The line e_d giving the difference in bias between an unprimed tube and the primed tube shows this to be about 32 volts as indicated by the difference 64–32 = 32 volts. This condition also allows sufficient margin so that the impulse voltage need not be critically adjusted. If e_d is not considered to be sufficient for the desired E_s value, a lower ratio between R_1 and R_2 should be used. For higher values of E_s, a higher ratio could be used. From similar lines or simple calculations the operating voltages may be determined for any case. When the method is understood, it will be found simpler and faster to compute the values directly, particularly if R_K is intended to be about the same size as R_1 and R_2. Examples of such calculations are given later.

Figure 11 shows some oscillograms of biasing conditions at a low-switching frequency $F_i = 88$ cycles per second. Figure 11*a* shows grid voltages to ground of all tubes and figure 11*b* the voltage at $R_1 - R_2$ midtap to ground. The high relative voltage drop across the grid resistance R_g of the conducting tube 2, as well as the relatively small influence of this conduction on the bias levels for primed and unprimed tubes, is indicated.

Triggering

With reference again now to the application of impulse voltage to the circuit of figure 8*a* the reader will see that the impulse voltage e_i is applied effectively from the grid of each type-885 tube to ground. Since R_g usually is large relative to R_K, the impulse voltage must have a peak value equal at least to the voltage by which the grid-bias voltage on the primed tube exceeds its breakdown voltage. The capacitor C_i should have a value of about 100 micromicrofarads or less for usual R_g values of about 200,000 ohms. Small values of C_i serve to steepen the impulse wave form and to keep the time constants of the grid circuits low. The resistances R_j are inserted (1) to keep the grid circuit of a conducting tube from appreciably decreasing the impulse terminating impedance, (2) to keep the grid impedance to ground as high as feasible with respect to R_K, and (3) to limit the initial peak grid current of a conducting tube to about one milliampere. The value of R_j depends also on the grid voltage at breakdown and series current-limiting resistances other than R_j. For example, if the grid voltage at breakdown is 11.5, R_j should have a minimum value of 11,500 ohms. The resistance R_g serves for impulse coupling and to keep the grid current small. Its value is not critical. Values of from 50,000 to 300,000 ohms are suitable.

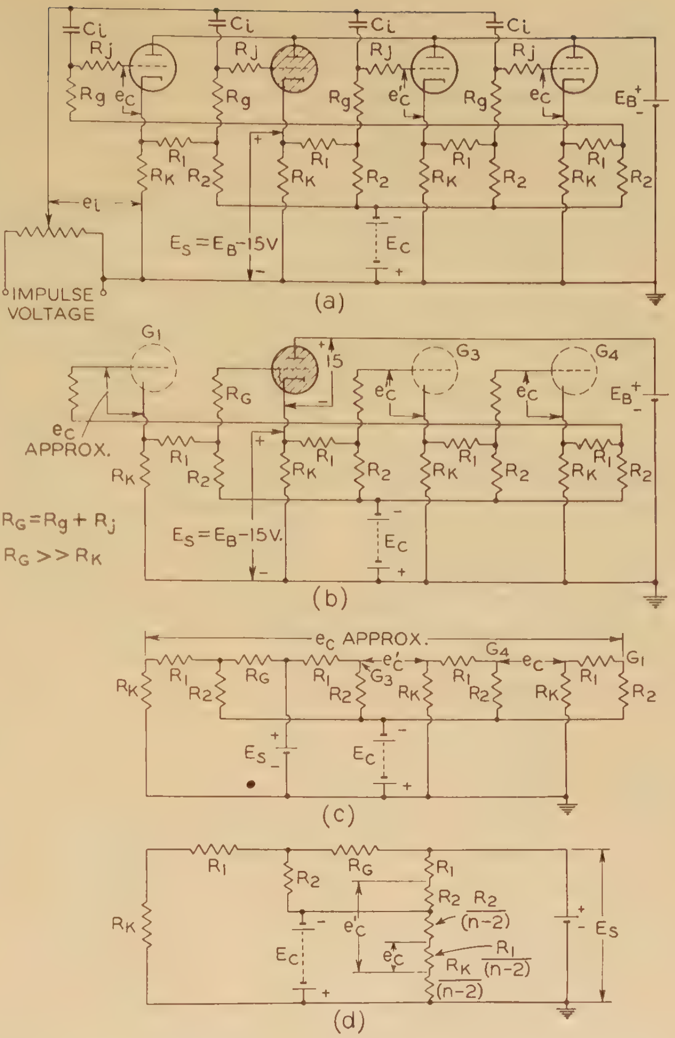


Figure 8. Equivalent circuits of the method used for supplying grid-bias voltage to several type-885 switching tubes from a common voltage supply

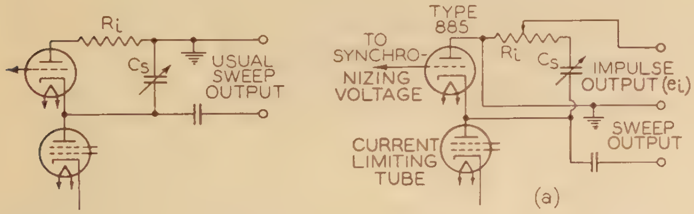


Figure 6. Essentials of a sweep circuit employing a current-limiting tube

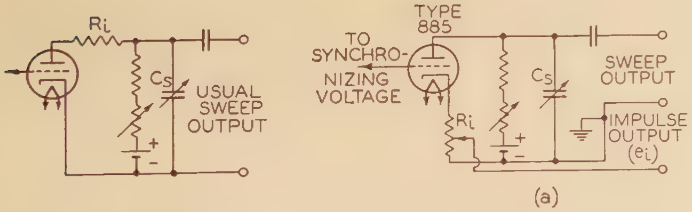


Figure 7. Essentials of a sweep circuit employing a current limiting resistor

Basic Voltage-Switching Circuit

Figure 12 shows the complete basic voltage-switching circuit. It is drawn for five switching circuits, but it is a symmetrical arrangement and may be contracted to four, three, or two switching circuits or extended to an indefinite number. The circuits to which the switched voltage is to be applied are, of course, to be connected to the cathode points indicated by the arrows in figure 12; the ground forms a common return.

Application of Basic Switching Circuit to the Observation of Multiple Recurrent Patterns

If the switched voltage is used to supply a control voltage to successive amplifier tubes so that the amplifier tubes are consecutively operative, then, as stated previously, different input voltages applied to the grids of the amplifier tubes may be amplified, may be made to appear in regular sequence across a common amplifier plate resistor, and may be applied directly or through an intermediate amplifier tube to a cathode-ray tube.

In the circuits following, the amplifier control voltage that is switched is the screen-grid voltage. Control may be obtained by switching the voltage on the number 3 grid of amplifier tubes such as the type 6*L*7, or by switching any other control-grid voltage on any suitable amplifier tube from cutoff to a normal value. Control-grid switching may be advantageous in some cases but is considered to be less flexible and less easily controlled.

For reference, one arrangement of a four-circuit electronic switch with auxiliary apparatus for obtaining four simultaneous wave-form patterns on a cathode-ray tube is shown in figure 13. Here are illustrated the voltage-switching circuit, the combination impulse sweep and the usual sweep circuit, the voltage supply, the amplifier tubes, and a delay switch. In this circuit, and in the circuit of figure 17, the reader should note that (1) the number of switching circuits may be altered, (2) the impulsing circuits may be any one of the types shown, (3) any suitable amplifier-tube arrangement may be used, (4) the voltage supplies are conventional, and (5) any suitable operating voltages may be used.

As its designation implies, the *delay* switch, in moving from "off" position 1 to the operating position 3, delays the application of the triggering voltage to the electronic switch until the electronic switch has the proper operating conditions. In position 1 temporary overpriming of one type-885 tube is provided to insure that it alone will become conducting as position 2 is reached and the plate voltage is applied to the overprimed tube; between positions 2 and 3 the overpriming is removed, the operating voltages are then correct, and the triggering voltage may be applied in position 3. The voltage appearing across the cathode resistor of each type-885 tube is supplied as a screen voltage to its associated amplifier tube; consequently, these transient voltages constitute screen voltages for the time they persist. Their effect, then, should be made as short in duration as is feasible. The time constants of the switch proper should be kept as low as is practical. To obtain time constants less than 10 × 10^{-6} second, however, requires that the steady-state plate currents be reduced so that fewer positive ions need be removed. The grid time constants also must be decreased proportionally. Using lower operating voltages allows lower operating currents and some decrease in the operating time constants. This statement applies to the basic electronic switch. Yet if such a switch is used to operate amplifier tubes singly in consecutive order, a somewhat further decrease in the effective duration of the transients of switching can be obtained.

Decreasing the Switching Interval

As the screen-grid (or other control-electrode) voltages

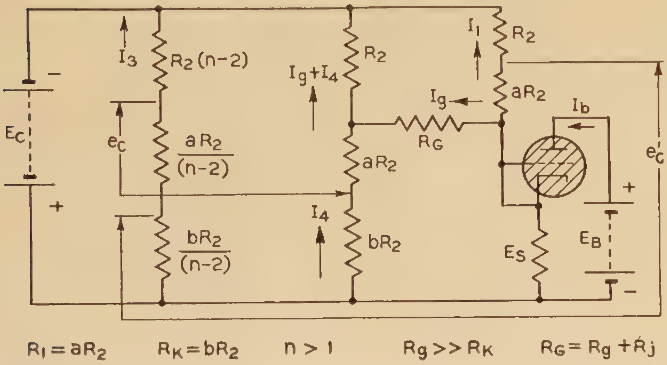


Figure 9. Diagram showing the steady-state current and voltage relations in an electronic switching circuit

General Case ($E_K \neq 0$)

$$e_c = aE_c/(1+a+b) \tag{5}$$

$$e_c' = E_c\left[\frac{a^2+a-b}{(1+a)(1+a+b)}\right]+\frac{E_s}{1+a} \tag{6}$$

$$e_d = e_c - e_c' = \frac{1}{1+a}\left[E_s - \frac{bE_c}{1+a+b}\right] \tag{7}$$

$$e_c = (a/b)E_k \tag{8}$$

$$E_c = [(1+a+b)/b]E_k \tag{9}$$

$$e_c' = \frac{1}{1+a}\left[E_k\left(\frac{a^2+a-b}{b}\right)+E_s\right] \tag{10}$$

$$e_d = [1/(1+a)][E_s - E_k] \tag{11}$$

$$a = (E_s - E_k - e_d)/e_d \tag{12}$$

$$b = \frac{aE_k(1+a)}{e_c'(1+a)+E_k-E_s} \tag{13}$$

$$R_K' = [(1+a)R_k]/(1+a+b) \tag{14}$$

$$R_2 = [(1+a+b)R_K']/[b(1+a)] \tag{15}$$

$$I_b = [E_s(1+a+b) - bE_c]/[R_k(1+a)] \tag{16}$$

$$R_G = \frac{(1+a+b)E_s - (a+b)(E_c + I_gR_2)}{(1+a+b)I_g} \tag{17}$$

$$R_3 = \frac{R_2(a+b)\left[\dfrac{bE_c}{1+a+b} - 0.1(E_s+15)\right]}{aE_c + 0.1(E_s+15)(1+a+b)} \tag{18}$$

Special Case ($E_K \doteq 0$, that is, E_K is substantially equal to zero, or $b << 1$ or a)

$$e_c = aE_c/(1+a) \tag{19}$$

$$e_c' = (aE_c + E_s)/(1+a) \tag{20}$$

$$e_d = E_s/(1+a) \tag{21}$$

$$I_b = \frac{E_s - E_c}{R_2(1+a)} + \frac{E_s}{R_K} \tag{22}$$

$$R_G = \frac{(1+a)E_s - a(E_c + I_gR_2)}{(1+a)I_g} \tag{23}$$

$$R_3 = -\frac{0.1aR_2(E_s+15)}{aE_c + 0.1(E_s+15)(1+a)} \tag{24}$$

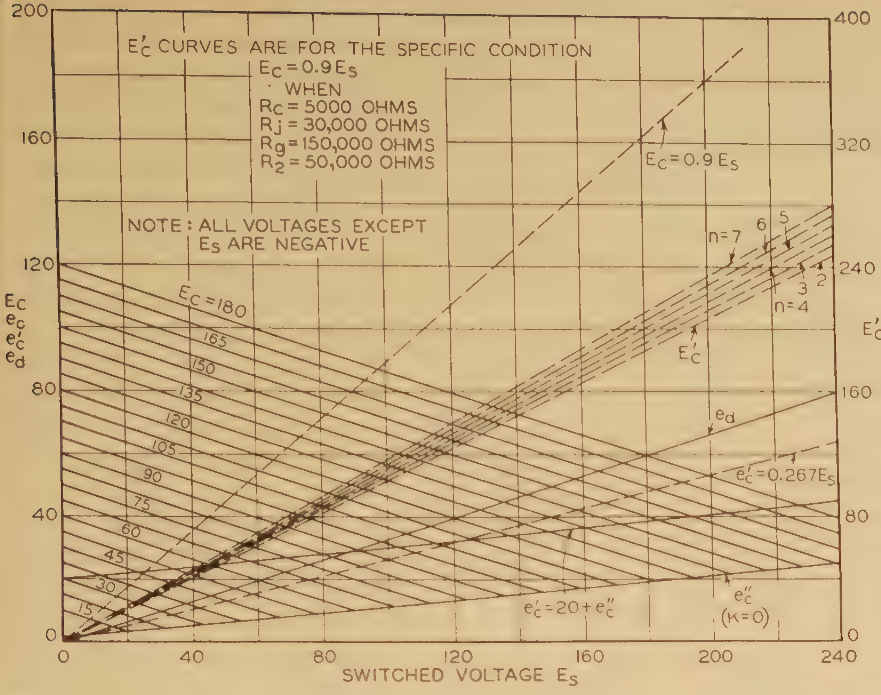
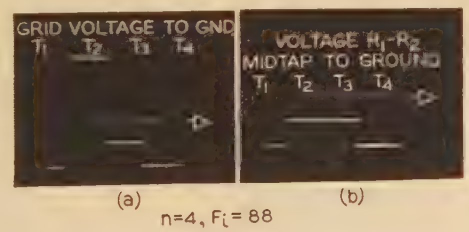


Figure 10. Curves used for the selection of the operating voltages of switching circuits

of the amplifier tubes are switched, two methods can be used to decrease the apparent duration of the transients. The first is to take full advantage of the fact that the transconductance g_m of sharp-cutoff multielectrode tubes drops rapidly with decrease in screen voltage. For example, the transconductance of type-6*J*7 tubes, which were used as the switched amplifier tubes in the circuits shown, ordinarily drops to one per cent or less for the usual unidirectional operating voltages (plate voltage $E_p = 250$, suppressor voltage $E_{c3} = 0$, and control-grid voltage $E_{c1} = -3$) as the screen-grid voltage E_{c2} drops from +100 to +20 volts. For each condition of the circuits used, the transconductance drops to one per cent or less as the transient screen voltage e_{c2} drops to 20 per cent of the steady-state value E_{c2}. For switched screen voltages, the E_{c2} value becomes the switched positive voltage E_s and the transient values are the various e_K values. Figures 4 and 5 show that for each value of n the e_K value of the longest positive duration identifies the tube that has just been shut off. For nonconducting tubes, however, the values of e_K drop almost to zero, or the steady-state voltages E_K across the cathode resistors are almost zero. The voltages E_K constitute the steady-state screen-grid voltages of the presumably inoperative amplifier tubes. These voltages are approximately zero for this first method of reducing the apparent transient time of switching and are made somewhat negative for the second method. This difference is used to distinguish between the two methods.

Figure 11. Oscillograms of grid-bias voltages at a switching frequency of 88 cycles per second



The amplifier switching circuit of figure 13 is an illustration of the circuit in which E_K is substantially equal to zero. Figure 14 shows four oscillograms taken with this circuit. For each, three wave-form patterns were obtained using three of the amplifiers; the fourth amplifier with no input signal was used for the zero line. For (*a*), (*b*), and (*c*) of this figure, the time constants of the basic switching circuit were the same, that is $C = 0.004$ microfarad and $R_K = 5{,}000$ ohms, but the switching or impulse frequencies were 200, 400, and 1,000 impulses per second, respectively. The two sweeps were synchronized so that the sweep frequency and the switching frequency F_i were the same. The signal frequency F_s, however, was kept at three times the switching frequency. The progressive increase in the switching time is readily noticed. In (*d*) F_i was increased to 5,000 cycles per second and F_s to 15,000 cycles per second, but the time constants were reduced by reducing C from 0.004 microfarad to 0.002 microfarad. The switching time then was about 20 per cent of a sweep cycle.

The values for biasing resistors of the amplifier switch of figure 13 have been computed by using the equations of figure 9 for the specific case in which $R_1 = 2R_2$ and R_1 and R_2 are large compared with R_K. A switched voltage E_s of 100 volts is desired so that the screen grids of the 6*J*7 tubes could be operated at this value. The other basic switching-circuit potentials are selected as previously described.

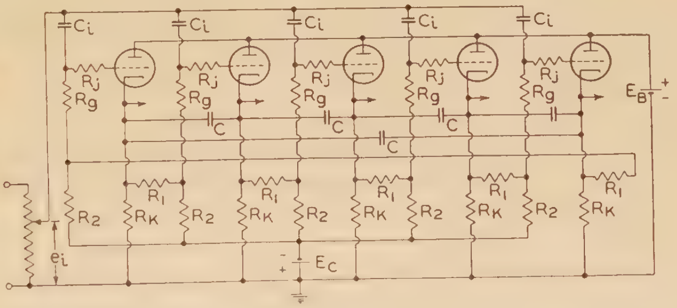
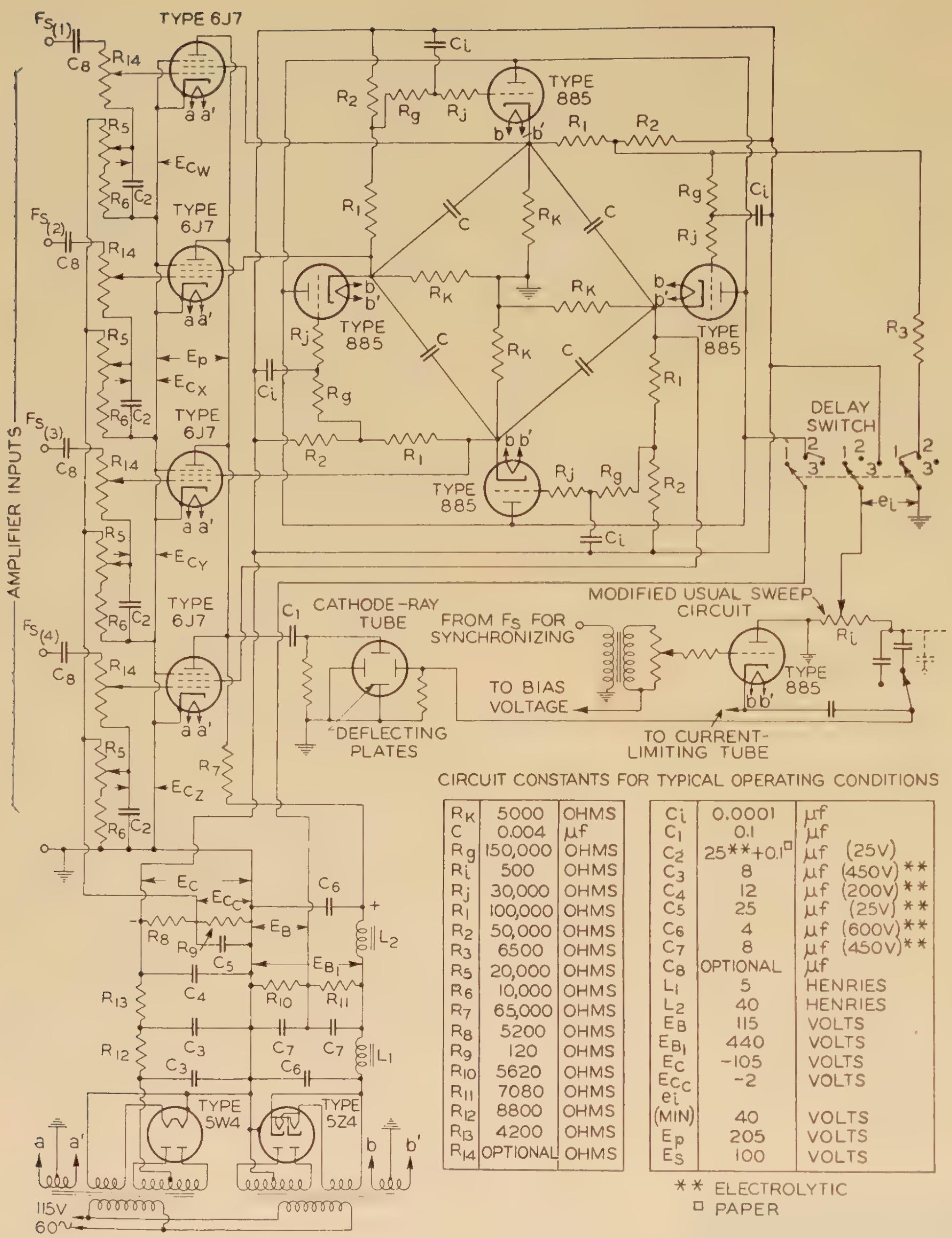


Figure 12. Diagram of a complete basic voltage-switching circuit

The second method of decreasing the apparent persistence of the transient of longest duration is to apply a



CIRCUIT CONSTANTS FOR TYPICAL OPERATING CONDITIONS

R_K	5000	OHMS
C	0.004	μf
R_g	150,000	OHMS
R_i	500	OHMS
R_j	30,000	OHMS
R_1	100,000	OHMS
R_2	50,000	OHMS
R_3	6500	OHMS
R_5	20,000	OHMS
R_6	10,000	OHMS
R_7	65,000	OHMS
R_8	5200	OHMS
R_9	120	OHMS
R_{10}	5620	OHMS
R_{11}	7080	OHMS
R_{12}	8800	OHMS
R_{13}	4200	OHMS
R_{14}	OPTIONAL	OHMS

C_i	0.0001	μf
C_1	0.1	μf
C_2	25**+0.1□	μf (25V)
C_3	8	μf (450V)**
C_4	12	μf (200V)**
C_5	25	μf (25V)**
C_6	4	μf (600V)**
C_7	8	μf (450V)**
C_8	OPTIONAL	μf
L_1	5	HENRIES
L_2	40	HENRIES
E_B	115	VOLTS
E_{B_1}	440	VOLTS
E_C	−105	VOLTS
E_{C_C}	−2	VOLTS
e_i (MIN)	40	VOLTS
E_p	205	VOLTS
E_S	100	VOLTS

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Figure 13. A four-circuit electronic switch with auxiliary apparatus for obtaining four wave-form patterns simultaneously on a cathode-ray tube

fairly large negative steady-state screen voltage E_K to all amplifier tubes, except the tube that is to be operative with E_s as its screen voltage. If this is done, the time is decreased so that each supposedly inoperative amplifier tube becomes actually inoperative after the instant of triggering. The important point is that this quicker action is obtained without change in the equivalent electronic-switch R_KC product. It is done by making the biasing resistors R_2 and R_1 for common grid bias of the same order as R_K. To illustrate the method, the transient voltage appearing across the cathode resistor of the tube that is not operating has been recomputed for a two-tube switch in which R_2 and R_1 are not of sufficiently high values to be neglected in comparison with R_K. The transient voltage e_K from cathode to ground of inoperative tube 1, in which interest chiefly lies, rises initially to a positive value of (2 E_s–E_K) volts and drops finally to the value E_K volts (see equation 25 of figure 15). Now if R_2 is made such a value, as given by equation 15, that the time constant is kept the same as for the condition that E_K is substantially equal to zero, the relative effective transient voltages for E_K of substantial magnitude may be directly compared with the case in which E_K is substantially equal to zero. In figure 15, three curves are drawn for such comparison purposes. Assuming as explained previously that an associated amplifier tube is inoperative when its e_K has dropped to 20 volts, it will be seen from curves *A*, *B*, and *C* that e_K reaches 20 volts when *t* is 23, 15, and 12.5 microseconds, respectively. Conditions for curve *B*, for example, give a resultant decrease in effective transient time of about 30 per cent from the conditions of curve *A*. The decrease is even greater for the actual circuits, since the peak values do not reach the computed values.

The method is illustrated further by the oscillograms of figure 16 for a three-circuit switch. E_K for the same three-circuit switch of figure 4*a* was almost zero. For (*a*) and (*b*) of figure 16, changes were made in the switching-circuit constants R_2, R_1, and R_K to provide for a fairly large value of E_K. R_2 was changed from 50,000 to 10,000 ohms, R_1 was changed from 100,000 to 200,000 ohms, and R_K from 5,000 to 6,000 ohms, so that the effective cathode resistance R_K' remained the same at 5,000 ohms. In (*a*), E_c was made −132 volts and in (*b*), −264 volts. The respective values of E_K were then −22 and −44 volts. The transient times when e_K = 20 volts for tube 2 for each of the conditions $E_K \doteq 0$, $E_K = -22$, and $E_K = -44$ volts are found from figure 15 to be approximately 17, 8, and 5 per cent, respectively; therefore, (*b*) of figure 16 shows a decrease of about 70 per cent in transient time from the condition where $E_K \doteq 0$. Further decrease may be obtained by increasing E_K but the advantage is not proportionally as great. This same method is, of course, applicable to any number of circuits. It is designated by the condition $E_K \neq 0$. The example illustrates the only major modification necessary to change from switch operation with $E_K \div 0$ to operation with $E_K \neq 0$. A change in the E_c value and supply may be necessary.

For chosen values of E_s, e_c', e_d, and E_d, the values of a and b may be selected by drawing bias lines as previously explained, but they may also be determined quickly and accurately by using the bias equations. Examples of such calculations are given later in conjunction with the complete diagram of the three-circuit amplifier-switch of figure 17 for which two sets of typical switching-circuit conditions are given.

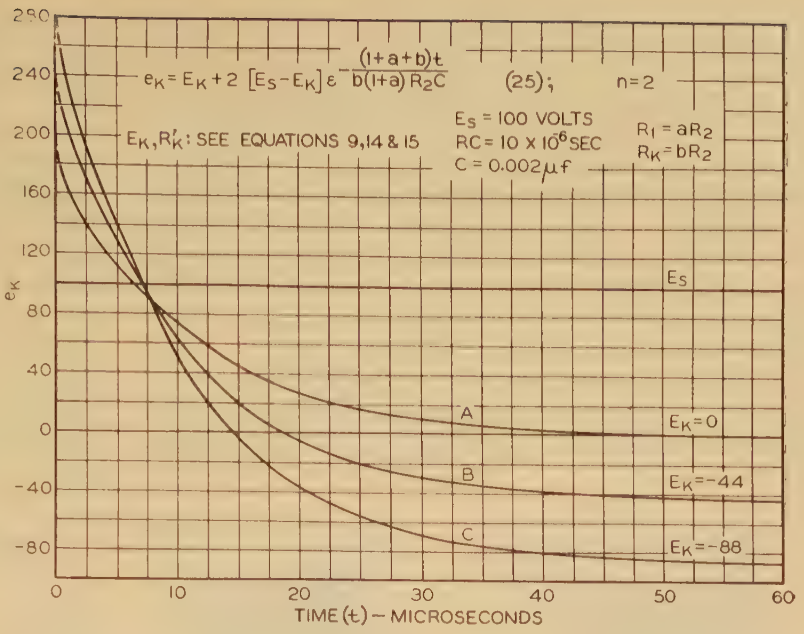


Figure 15. Curves of transient voltage from cathode to ground versus time, showing the variation with magnitude of E_K

A—$e_K = 200\epsilon^{-0.1t}$ 1; $a >> b$ R_K = 5,000 ohms

B—$e_K = -44 + 288\,\epsilon^{-0.1t}$ $a = 2$, $b = 0.6$, $E_C = -264$ volts, R_2 = 6,000 ohms, R_K' = 5,000 ohms

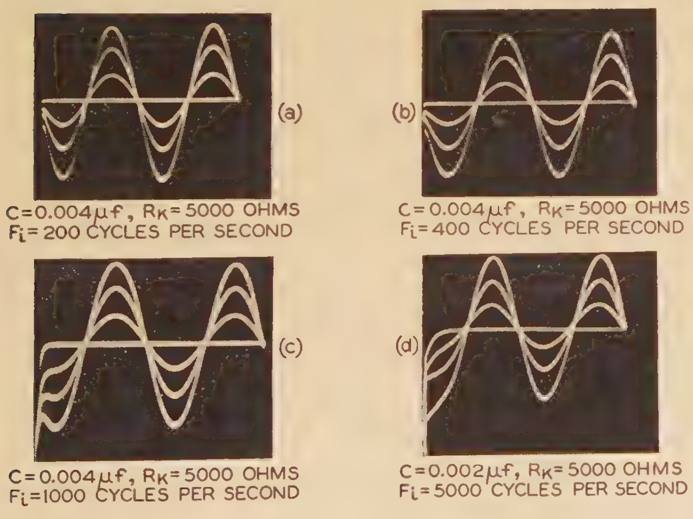
C—$e_K = -88 + 376\epsilon^{-0.1t}$ $a = 2$, $b = 0.6$, $E_C = -528$ volts, R_2 = 6,000 ohms, R_K = 5,000 ohms

For the first set it has been assumed that a switched voltage E_s of 100 volts and an acritical operational margin for impulse adjustment is desired and that a maximum negative screen voltage E_K of -40 volts is to be used. Acritical impulse control will be obtained if the priming bias e_c' is kept 20 volts from the breakdown bias e_c''. Since e_c'' is given by $(E_s + 15) / \mu$, which is equal to $(100 + 15)/10$, or 11.5 volts in this instance, e_c' should be -31.5 volts. Suppose also that the difference in bias, $e_d = e_c - e_c'$, between the unprimed tube and the tube is made -40 volts. Having the values E_s = 100 volts, $E_K = -40$ volts, $e_c' = -31.5$ volts and $e_d = -40$ volts, it follows that the value of a obtained from equation 12 of figure 9 is 2.5. When this value of a is substituted in equation 13 of figure 9, the value of $b = 1.4$ is obtained. The value of E_c then is -140 volts, from equation 9 of figure 9.

The actual value of R_K' the equivalent cathode resistance, is not critical but should be chosen so that the $R_K'C$ product is not much less than ten for R_K' in ohms and C in microfarads. However, because R_K' constitutes the impedance of the amplifier screen grid to its cathode, R_K' should be kept well below 50,000 ohms in value. The lower limit of R_K' will be set by the peak plate current of a type-885 tube at breakdown, but a value somewhat larger usually is desirable for two reasons: (1) shutoff will be faster with lower plate current, and (2) regulation of the bias supply generally used for E_c need not be as good as is required for a lower value of R_K'. If R_K' is made 5,000 ohms, then from equation 15 of figure 9, R_2 = 5,000 ohms, and since $R_1 = aR_2$ and $R_K = bR_2$, R_1 = 12,500 ohms, and R_K = 7,000 ohms. The steady-state plate current through the conducting tube is 28 milliamperes, from equation 16.

If the grid current of the conducting tube is limited to one milliampere, then, from equation 17, R_G is 207,000 ohms. Since R_j should be at least equal to $1{,}000\ [(E_s + 15)/\mu] = 1{,}000\ (115/10)$ = 11,500 ohms, R_g is made 200,000 ohms and R_j, 15,000 ohms. The foregoing conditions allow C to be made 0.002 microfarad or less. It is given as 0.002 microfarad in the first set of conditions.

The second set of switching conditions for figure 17 gives an example of further reduction in the apparent switching interval. A lower switched voltage, closer biasing differentials between primed and unprimed tubes, and a relatively higher steady-state negative voltage E_K across R_K are used. The lower switched voltage and the closer bias differences allow lower actual time constants, and the relatively higher E_K value or the greater ratio of E_K to E_s gives the apparent reduction in time constants. Operation with smaller biasing differentials requires good regulation of all voltage supplies and close control of the impulse voltage. The time constants of the grid circuits should also be kept as low as, or lower than, the plate-current time constants.



C=0.004μf, R_K=5000 OHMS
F_i=200 CYCLES PER SECOND

C=0.004μf, R_K=5000 OHMS
F_i=400 CYCLES PER SECOND

C=0.004μf, R_K=5000 OHMS
F_i=1000 CYCLES PER SECOND

C=0.002μf, R_K=5000 OHMS
F_i=5000 CYCLES PER SECOND

Figure 14. Oscillograms taken with the circuit of figure 13

For the three-circuit amplifier switch assumed, suppose that E_s and E_K are tentatively chosen as 50 and −35 volts, respectively. The breakdown-bias voltage e_c'' is $-(E_s\ 15)/10$, or −6.5 volts. With close control of the impulse voltage and good regulation of the voltage supplies, the priming bias e_c' can be made about −20 volts. The transient rise in plate voltage (see figure 4) will be about ten per cent of E_s, or five volts. The value of the bias voltage e_c on the unprimed tube then should be made about 25 volts more negative than the e_c' value, or about −45 volts.

If the values of e_c and E_K are substituted in equation 8 of figure 9, $a = 1.28b$. Substituting this value of a and the values of e_c' E_K, and E_s in equation 13 gives $b = 1.89$. Hence, $a = 2.42$. If for convenience, however, a is made 2.5 and b is made two, then the values $E_K = -36$, $e_c' = -20.7$ and $e_c = -45.1$ volts satisfy the conditions for $E_s = 50$ volts. These values closely approximate the desired values. Arbitrarily choosing a compromise value of 3,800 ohms for R_K' to obtain an R_K value of 6,000 ohms, makes $R_2 = 3{,}000$ ohms, and $R_1 = 7{,}500$ ohms. The steady-state plate current I_b is, from equation 16, 22.6 milliamperes. For a conducting-tube steady-state grid current of one milliampere, the series grid resistance $R_G = R_g + R_f$ becomes, from equation 17 of figure 10, 129,000 ohms. R_f should have a minimum value of $1{,}000\ e_c'' = 6{,}500$ ohms, and for convenience, R_g is made 120,000 ohms. The coupling capacitors C_i are 30 micromicrofarads to provide grid-circuit time constants lower than those of the cathode circuits. With this value of C_i the minimum peak value of triggering impulse voltage applied becomes 80 volts. The value of C may not be reduced much below $C = 0.0015$ microfarad for stable operation. Hence, this value of C is used. The $R_K'\ C$ value, therefore, is 5.7 with C in microfarads and R in ohms. For R_3, which is connected momentarily in the switching circuit proper to cause only one tube to break down just before the triggering voltage is applied, the maximum value allowable for any set of conditions may be calculated from equation 18 of figure 9. The maximum allowable value of R_3, however, is based on having either battery supplies for E_s and E_c, or rectified supplies with perfect regulation. For usual rectified-alternating-voltage sources, R_3 may be made somewhat larger than the value obtained from equation 18.

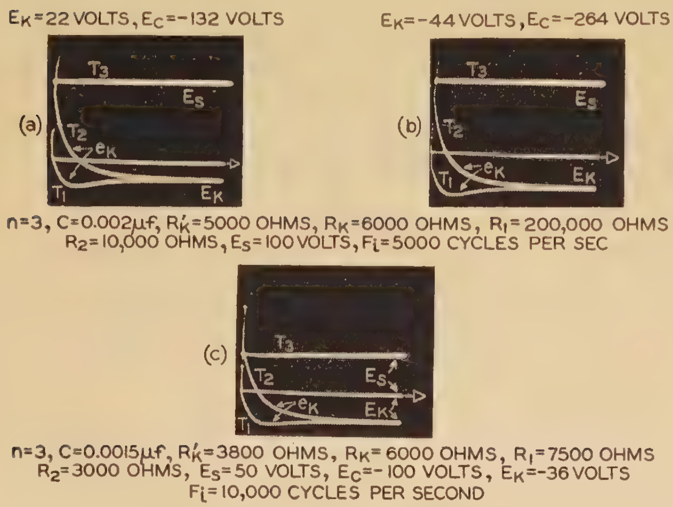


Figure 16. Oscillograms for a three-circuit switch, demonstrating the effect computed for figure 15

In (c) of figure 16 are shown the transient voltages e_K across the cathode resistors R_K for the second set of conditions for an impulse frequency F_i of 10,000 cycles per second. The longest effective transient time is about eight per cent of a sweep cycle.

The application of this complete switch-amplifier system to the simultaneous observation of recurrent patterns again is illustrated by figure 18. Here out-of-phase signals with a frequency of 10,000 cycles per second ($F_{s1} = F_{s2} = 10{,}000$) are applied to the inputs of two amplifier tubes while the third amplifier is used for the zero reference line. The impulse or switching frequency F_i also is 10,000 cycles per second. The pattern or picture frequency F_p is, of course, $10{,}000/3 = 3{,}333$ cycles per second; that is, each of these patterns appeared 3,333 times per second. The switching conditions are those of case 2 (figure 17), except that the amplifier plate loads are 20,000 instead of 10,000 ohms as shown in the figure. For the 20,000-ohm plate loads, the effective switching time is about twice as large as is indicated in (c) of figure 16, because the amplifiers shown in figure 18 did not pass all of the highest switching frequencies.

Amplifiers Used With Electronic Switches

Although the amplifier design required for electronic switches is conventional except for the possible use of a peaking coil, the operating conditions are somewhat unusual. The amplifier should be designed to pass the higher-frequency components of the switched voltage to the screen grid. Greater amplifier gain can be obtained, if desired, with additional amplifier stages. Push-pull amplifier output may be obtained by ordinary single-ended to push-pull transformation methods. Push-pull switched amplifier circuits are feasible for balanced amplifier inputs also. Twice as many switched amplifier tubes, are required, of course, but no more switching circuits are necessary. The input circuits must be isolated effectively with regard to grid bias as well as to the different input signals. Separate individual bias controls are employed, therefore, but a common fixed rectified bias source, properly by-passed, may be used. The separate grid-bias controls allow the steady-state plate current of each amplifier to be adjusted to the same value provided a d-c reference line is not desired.

In order to maintain the correct amplifier voltage conditions after the initial bias adjustment has been made, one bias value should be left fixed, and subsequent adjustments should be made only on the bias potentiometers provided for the other tubes.

To use at least one plate voltage as a direct-voltage reference line is desirable at times. This may be done by adjustment of the bias of one or more amplifier tubes without input signal. Any amplifier without input signal can, of course, be used as a zero reference line. For each reference line desired, an additional switching circuit should be provided.

The amplifiers require that one side of a signal-input circuit be grounded. The wave form of the potentials of any circuit points to ground may be easily observed. The wave forms of currents through isolated circuits may have to be obtained by the use of transformers, or by analysis of component wave forms.

No filtering of the switched screen voltage is necessary or desirable. It should not be attempted unless the effect on the switching is considered. The supplied screen voltage is kept constant inherently, except during the switching transient time, by the regulation of the switch itself.

The amplifier arrangement of the three-circuit switch of figure 17 shows a method of using two stages to obtain relatively higher gain and output voltage. Such an amplifier is suitable for lower-frequency switching. The first stage, operating at relatively low plate voltage and gain, actuates a second stage operating at higher plate voltage and additional amplification.

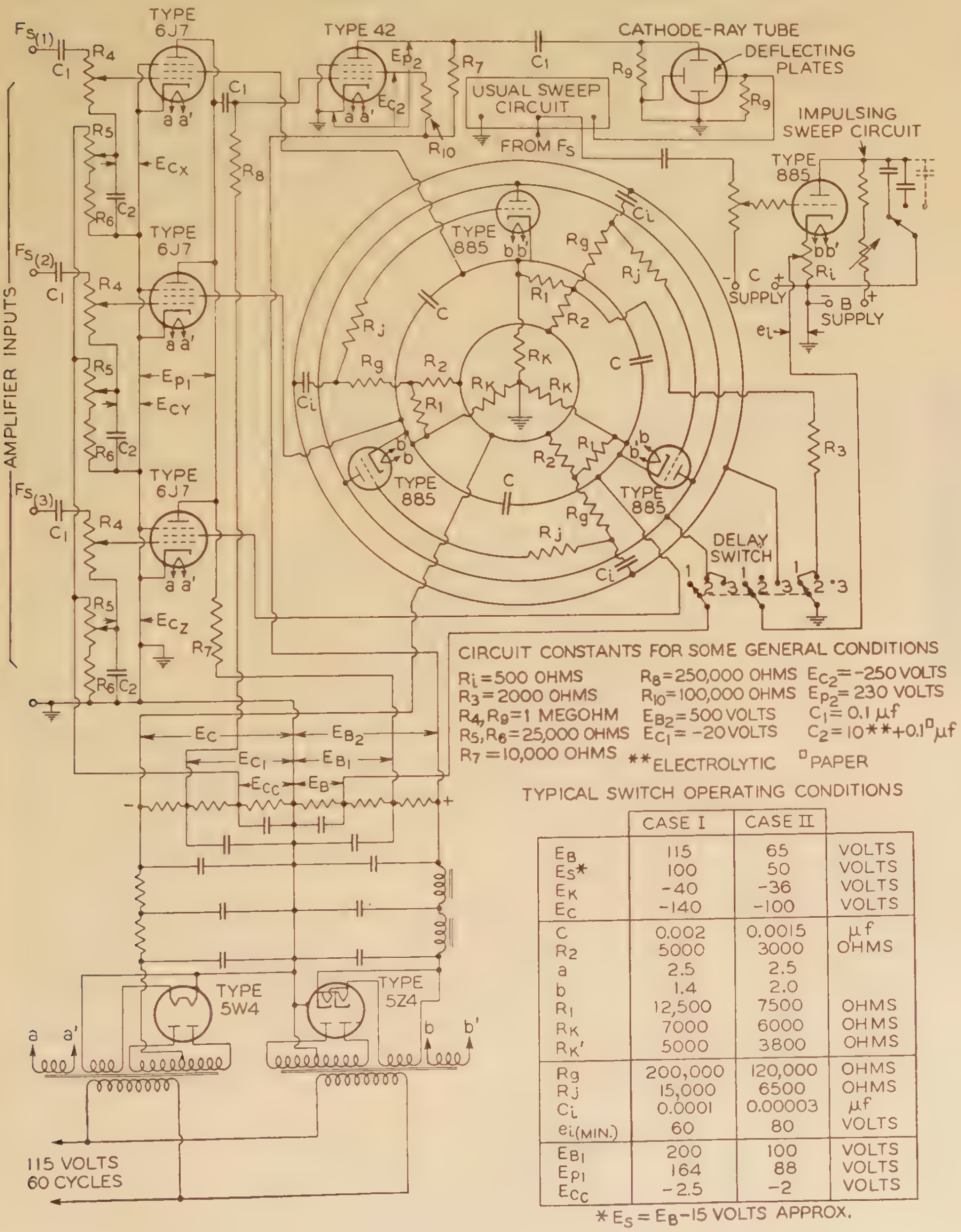
Additional Applications of the Basic Switching Circuit

SWITCHING COMMON GROUND CIRCUITS

The basic switching circuit can be used directly to operate consecutively different circuits with a common ground. As examples, relays may be actuated up to the limit of their operating frequency and separate amplifiers or oscillators may be turned off or on effectively by switching some controlling voltage.

SWITCHING ONE CIRCUIT TO DIFFERENT VOLTAGES

Where amplifier tubes are associated with the type-885 switching tubes, as for viewing multiple patterns on a cathode-ray tube, the amplifier tubes may be used to supply stepped direct voltages from their common plate load to a single circuit. This is done without input to the amplifiers by adjusting the grid bias or by tapping the switched voltage E_s for different screen-grid voltages to each amplifier tube so that a different voltage is obtained across the common plate load for each amplifier tube. An example of this application is the determination of vacuum-tube characteristic curves. By the switching of some control voltage through a series of fixed values a set of curves of a tube under test can be viewed on a cathode-ray tube screen.



CIRCUIT CONSTANTS FOR SOME GENERAL CONDITIONS

R_i = 500 OHMS R_8 = 250,000 OHMS E_{C_2} = −250 VOLTS
R_3 = 2000 OHMS R_{10} = 100,000 OHMS E_{P_2} = 230 VOLTS
R_4, R_9 = 1 MEGOHM E_{B_2} = 500 VOLTS C_1 = 0.1 μf
R_5, R_6 = 25,000 OHMS E_{C_1} = −20 VOLTS C_2 = 10** + 0.1□ μf
R_7 = 10,000 OHMS **ELECTROLYTIC □PAPER

TYPICAL SWITCH OPERATING CONDITIONS

	CASE I	CASE II	
E_B	115	65	VOLTS
E_S*	100	50	VOLTS
E_K	−40	−36	VOLTS
E_C	−140	−100	VOLTS
C	0.002	0.0015	μf
R_2	5000	3000	OHMS
a	2.5	2.5	
b	1.4	2.0	
R_1	12,500	7500	OHMS
R_K	7000	6000	OHMS
R_K'	5000	3800	OHMS
R_g	200,000	120,000	OHMS
R_j	15,000	6500	OHMS
C_i	0.0001	0.00003	μf
$e_{i(\text{MIN.})}$	60	80	VOLTS
E_{B_1}	200	100	VOLTS
E_{p_1}	164	88	VOLTS
E_{CC}	−2.5	−2	VOLTS

*$E_S = E_B - 15$ VOLTS APPROX.

Figure 17. Complete diagram of a three-circuit amplifier-switch

FREQUENCY DIVISION

By reference to figures 4 and 5, particularly figure 5, showing the transient voltages occurring across the series cathode resistors of the basic voltage-switching circuit, as shown in figure 12, the reader will see that for each complete switching cycle around such a symmetrical arrangement of switching tubes, the highest peak transient voltage occurs across the cathode resistor of the tube just being shut off (for any value of *n*) and that across any one cathode resistor this transient of highest value will occur only once in a complete switching cycle. Since this highest transient peak voltage, of magnitude approximately equal to twice the switched voltage E_s for $E_k \div 0$, appears at a frequency $1/n$ times the original impulse frequency F_i, it may be used to supply impulses to another electronic switch at a frequency F_i/n. This method may be carried on indefinitely; the output frequency of the last switch being $F_i/n_1\, n_2\, n_3 \ldots . n_n$. Since the values of n_1, n_2, n_3, ... may be different, practically any integral frequency division is possible. The output of the last switch may have the usual character of E_s or be made impulsive acording to the filtering used.

Operational Notes

PHOTOGRAPHING

Although patterns obtained simultaneously may be photographed, it is necessary with high amplifier gains and desirable with low amplification, that the anode-voltage supply for the electronic switch and associated amplifiers should have good regulation. An exposure meter is helpful in predetermining the photographic requirements.

WIRING

All leads carrying high-frequency currents should be kept short, small, and well separated, particularly for high-frequency switching. Resistances and other circuit constants should, also, be chosen to meet the requirements of high-frequency operation.

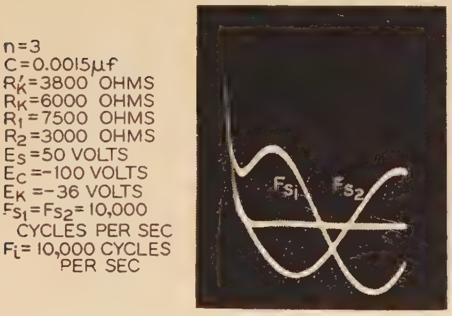


Figure 18. Oscillogram showing the application of the circuit of figure 17 to the observation of recurrent patterns

PERMISSIBLE VARIATIONS IN CIRCUIT CONSTANTS

All constants nominally identical should in general be held as closely as feasible to the same values. The permissible departure from nominal values depends on the application.

RELATION OF THE TRIGGERING FREQUENCY TO THE SIGNAL FREQUENCY AND TO THE PATTERN FREQUENCY

All signal frequencies F_s must bear an integral ratio to the switching frequency F_i; otherwise, a nonexistent phase shift will be indicated between patterns of integral-frequency ratios. If a value of F_s is equal to $F_i/2$ or $F_i/4$, a half-wave or quarter-wave of F_s is shown, respectively. The pattern frequency, that is, the number of times a particular pattern is repeated per second, ordinarily is equal to F_i/n; hence, F_i bears the integral ratio n to F_p.

FORMATION OF N-TUBE SWITCHING CIRCUITS

No definite limit can be set for the number of switching tubes that can be used in an electronic switch without giving consideration to the application. Thus, at an impulse frequency F_i of 60 cycles per second, four circuits are about the limit for visual observation, since the pattern frequency F_p would be 15 cycles per second—not considered objectionable; if n equals five or six, F_p would be 12 and 10, respectively, for which flicker perhaps would be considered objectionable. For photographic purposes, however, the limit may be determined by the number of distinguishable wave forms. For example, 300 impulses per second (F_i), which would produce 15 patterns, each having a repetition frequency of 20 pictures per second (F_p) probably would be acceptable. For frequency division at low switching frequencies, a very large number of switching tubes probably could be operated successfully in each switch. At switching frequencies of 5,000 cycles per second or more, the number of circuits should not be greater than necessary in order that the time constants may be kept as low as possible. For these frequencies, every means should be used to keep the apparent transient time low.

Conclusions

The development of one type of basic switching circuit suitable for from two to a large number of controlled circuits has been discussed and some applications described. Emphasis, however, has been placed on the observation of multiple recurrent patterns on the screen of a cathode-ray tube.

This latter application allows the simultaneous viewing of phase displacement or relative wave forms of two or more currents or voltages, or both, as for example, the input and output voltages of an amplifier or filter. Circuits may be switched at frequencies from 0 to 50,000 cycles per second or more depending on the permissible interval for the switching. With a three-circuit switch for this application, the effective switching interval may be made less than ten per cent of a sweep cycle at a switching frequency of 10,000 cycles per second. The switching interval at lower switching frequencies will be progressively less.

The other applications described include (1) the switching of circuits with common ground, (2) the switching of one circuit to different voltages and (3) the obtaining of frequency division.

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News

Of Institute and Related Activities

Washington Provides Ideal Setting for the Institute's 1938 Summer Convention

WASHINGTON, D.C., is the city which perhaps every citizen of the United States plans to visit. It ranks with London and Paris as one of the great capitals of the world. The 1938 AIEE summer convention to be held there June 20–24 offers an extraordinary opportunity for combining business, pleasure, sightseeing, and education amid the national shrines, in a city that is neither northern nor southern, neither eastern nor western. Here are neighbors from every state. Within short distances are the Atlantic Ocean and Chesapeake Bay beaches, the mountain resorts of Virginia, and the Shenandoah Valley and its famous caves and historical spots relating to the founding of the Republic and the Civil War. Convention headquarters will be the Mayflower Hotel.

In the city are so many points of interest that the visitor will have to select rather than wonder what is to be seen. One may take a 500-foot vertical hike (or an elevator) up the Washington Monument, from which can be seen the skyline of the city from the one side and Virginia on the other. For the more serious minded, there are the Capitol and Congress, which may be in session at the time of the convention.

Washington is not an industrial city so that inspection trips to factories and power plants, features of many conventions, will be limited. However, there will be several from which members can select. Members desiring information before coming or who wish to see something especially, or contact a Government department may do so through the chairman of the publicity committee, H. E. Way, 155 East Quincy Street, Chevy Chase, Md.

Technical Sessions

A technical program, now in a formative stage and tentatively comprised of ten technical sessions and six conference sessions, promises to bring forth new developments in several different branches of the electrical industry. Technical sessions on the following subjects tentatively are scheduled, power transmission, communication, education, lightning protection, selected subjects, power system stability and electrical machinery, electronics, symposium on fluorescent lighting, fault interruption, and instruments and measurements. Subjects of the conference sessions are: basic sciences (two), modernization of power plants, power requirements in electrochemical and allied industries, electrical machinery, and electronics. The symposium on fluorescent lighting is of noteworthy interest. The development of this new light source with its pleasing color effects and attendant economies will be described thoroughly in several papers, and the session will conclude with a general lighting demonstration lecture by A. L. Powell (A'13, F'36) supervising engineer, incandescent lamp department, General Electric Company, New York, N. Y., and past-chairman of the AIEE committee on the production and application of light. Details of the technical program are scheduled for announcement in the June issue.

Inspection Trips in Washington

A program of inspection trips in Washington and in the near vicinity has been planned to include many points of interest. Arrangements have been made by which the following buildings and plants may be inspected on each day during the convention, except where noted otherwise. Guides will be available at all locations:

1. **Bureau of Standards.** This is an institution, operated by the Federal Government, devoted to the development of methods, standards of measurement, standard constants, and standards of quality performance, and practices.

2. **New High-Voltage Generator of the Department of Terrestial Magnetism of the Carnegie Institution of Washington** (Monday, Tuesday, and Friday only). This is an electrostatic machine capable of delivering constant potential at controlled voltages from 500,000 volts to 5,000,000 volts. The special steel pressure tank and building with underground laboratory rooms already are constructed to house this apparatus, and it is anticipated that the generating equipment will be ready for use before June.

3. **United States Navy Yard.** The guns for the Navy are constructed here, as well as the delicate and accurate apparatus for sighting and controlling their discharge.

4. **New Building of the Department of the Interior.** This represents the latest ideas and designs of mechanical equipment in the construction of a Government office building.

5. **United States Central Heating Plant.** This plant furnishes heat to practically all of the Government-owned buildings in the downtown area of Washington.

6. **Department of Justice—Federal Bureau of Investigation.** The investigation of Federal offenses, including kidnaping, and robbery of national banks and the United States mail, is centered here. Laboratories for chemical analysis, photography, and other scientific aids for detection of crime are maintained. Special arrangements for receiving the AIEE delegates at the Federal Bureau of Investigation will be made and definite hours set for this visit.

7. **United States Naval Observatory.** The function of this Federal-operated plant is to determine accurate time through daily astronomical observations and other astronomical data required by the Navy Department.

8. **Bureau of Engraving and Printing.** At this establishment, all stamps (postage, revenue, and tax), paper currency, and bonds issued by the United States Government are engraved and printed.

Principal Hotels in Washington, D. C., and Rates

Hotel	Single Room	Double Room
Downtown Area		
Mayflower, Connecticut Avenue & DeSales Street (convention headquarters)	$3.50–$6.00	$5.50–$10.00
Ambassador, 1412 K Street	$3.00	$5.00–$ 7.00
Burlington, 1120 Vermont Avenue	$2.50–$3.50	$3.50–$ 4.50
Colonial, 1156—15th Street	$2.50–$3.00	$3.50–$ 4.00
Hamilton, 14th & K Streets	$3.00–$4.00	$5.00–$ 7.00
Harrington, 11th & E Streets	$3.00–$3.50	$4.00–$ 7.00
Hay-Adams House, 800—16th Street	$3.00–$5.00	$4.50–$ 7.00
Carlton, 923—16th Street	$4.00–$6.00	$8.00–$ 9.00
Fairfax, 2100 Massachusetts Avenue	$3.00–Up	$4.00–Up
Lafayette, 16th & Eye Streets	$3.00–$3.50	$4.00–$ 6.00
Lee House, 15th & L Streets	$3.50–$4.00	$5.00–$ 8.00
Martinique, 1211—16th Street	$3.00–$3.50	$4.00–$ 6.00
Powhatan, 18th Street & Pennsylvania Avenue	$2.50–$3.50	$4.50–$ 6.00
Washington, 15th Street & Pennsylvania Avenue	$3.50–$4.50	$5.00–$ 7.00
Willard, 14th Street & Pennsylvania Avenue	$3.50–$4.50	$5.00–$ 7.00
Raleigh, 12th Street & Pennsylvania Avenue	$3.00	$5.00–$ 5.50
Residential Area		
Wardman Park, 2660 Woodley Road	$3.00	$5.00
Shoreham, 2500 Calvert Street	$4.00	$6.00
Capitol-Plaza Area		
Dodge, 20 E Street	$2.00–$5.00	$3.50–$ 8.00
Plaza, 331 First Street, N.E.	$2.50–$3.00	$3.50–$ 4.00
Commodore, North Capitol & F Streets	$2.50–Up	$3.50–Up
Bellevue, 15 E Street	$2.00–$2.50	$3.50–$ 4.00
Carroll Arms, First & C Streets, N.E.	$3.00–$3.50	$4.50–$ 7.00

Tentative Schedule of Events

Eastern Standard Time; See Separate Schedule for Sports

Monday, June 20

9:00 a.m.—Registration

10:00 a.m.—Opening Session
- Address of Welcome by Doctor William McClellan, honorary chairman
- Annual Business Meeting
  - Annual report of board of directors, in abstract, by H. H. Henline, national secretary.
  - Report of committee of tellers on (*a*) election of officers, and (*b*) constitutional amendments
  - Introduction of and response from president-elect
- Presentation of Lamme Medal to Doctor R. E. Doherty
- Presentation of prizes for papers

2:00 p.m.—Inspection trips
- Conference of officers, delegates, and members

3:00 p.m.—Separate conferences
- (*a*) Section delegates
- (*b*) Student Branch counselors

7:00 p.m.—Student Branch dinner

8:30 p.m.—President's reception at Mayflower Hotel—dancing 9:00–12:00

Tuesday, June 21

9:30 a.m.—Power transmission
- Communication
- Education
- Conference on basic sciences

2:00 p.m.—Conference of officers, delegates, and members
- Inspection trips

7:30 p.m.—Dinner-dance at the Congressional Country Club

Wednesday, June 22

9:30 a.m.—General session

2:00 p.m.—Inspection trips
- Visit to Mount Vernon

4:00 to
6:00 p.m.—Tea at Doctor McClellan's, Burgundy Farm, Alexandria, Va.

Thursday, June 23

9:30 a.m.—Lightning protection
- Power-system stability and electrical machinery
- Selected subjects
- Electronics

12:30 p.m.—Board of directors' luncheon meeting—Mayflower Hotel

2:00 p.m.—Inspection trips
- Conference sessions:
  - (*a*) Modernization of power plants
  - (*b*) Electrical machinery
  - (*c*) Electronics
  - (*d*) Power requirements in electrochemical and allied industries

3:00 p.m.—Conference of vice-presidents, District secretaries, and counselor delegates

7:00 p.m.—Dinner—Mayflower Hotel
- Address: Doctor William McClellan, president of American Engineering Council.
- Presentation of Gaston Planté Medal to Doctor George W. Vinal by the French Ambassador
- Addresses by:
  - President W. H. Harrison
  - President-Elect John C. Parker
- Introduction of past-presidents
- Award of prizes for sports events

Friday, June 24

9:30 a.m.—Symposium on fluorescent lighting
- Fault interruption
- Instruments and measurements
- Conference on basic sciences

2:00 p.m.—Inspection trips

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9. Buzzard Point Power Plant. This is the base-load station of the Potomac Electric Power Company for the Washington system in connection with the Benning steam plant and the 230-kv transmission line from Safe Harbor (Pa.) on the Susquehanna River.

10. New Installation of Dial Telephone Equipment. The new Dupont central office of the Chesapeake and Potomac Telephone Company is the latest office of this type to be placed in service in Washington.

OUT-OF-TOWN INSPECTION TRIPS

Tuesday, June 21. Inspection of the cable and wire manufacturing plant of the Western Electric Company at Point Breeze, Baltimore, Md. At this plant is manufactured all of the rubber-insulated wire, submarine cable, and quadded cable used by the Bell System.

Thursday, June 23. Inspection of the 56-inch hot-strip mill of the Bethlehem Steel Company, Sparrows Point, near Baltimore, Md. This is the latest in hot-strip mills for the production of sheet metal.

Friday, June 24. Inspection of the Safe Harbor (Pa.) hydroelectric station of the Pennsylvania Water and Power Company. This will be an all-day trip.

POST-CONVENTION TRIPS

In addition to trips during the convention, arrangements will be made, provided a sufficient number register for the purpose, to include several post-convention trips. These have been planned as follows:

1. Annapolis tour, leaving Mayflower Hotel at 2:00 p.m., Friday, returning at 6:00 p.m., covering the city of Annapolis and the United States Naval Academy, with a guide to explain the points of interest. $1.50 per person round trip; minimum number 15.

2. Gettysburg (Pa.) tour. Leave Mayflower Hotel 8:30 a.m., returning 6:30 p.m. Includes lunch at Gettysburg, tour with guide over the battlefield, and visit to the Barbara Fritchie House in Frederick, Md. $4.15 per person; minimum number 15.

3. Tour to Luray Caverns and Skyline Drive, leaving Saturday, 8:00 a.m. and returning at 6:00 p.m. Includes lunch and admission to the Caverns and 31 miles of Skyline Drive. $5.50 per person; minimum number 15.

4. Three-day trip through Virginia. This includes Old Point Comfort, Yorktown, Williamsburg, Jamestown, Richmond, Charlottesville, Wakefield, and Fredericksburg. This trip will be arranged starting Saturday morning at 8:00 a.m., returning about 6:00 p.m. Meals and rooms at hotels included. $24.25 per person; minimum number 15.

SPORTS AND ENTERTAINMENT

Sports and social activities of the convention will center at the beautiful congressional country club situated in Maryland, near the banks of the historic Potomac and almost in sight of the Capitol dome. Club facilities include spacious grounds and gardens, a large outdoor swimming pool, and a commodious club house.

Arrangements have been made for golf tournaments for the Mershon and Lee trophies, and also a tournament for the Mershon tennis trophy and a variety of men's and women's single and double tennis events. The detailed program proposed is as follows:

Monday, June 20

1:00 p.m.—18 holes of medal play on a handicap basis and qualifying round for the Mershon and Lee trophies.

2:00 p.m.—Table-tennis tournament—men and women.

2:00 p.m.—First round men's tennis singles.

3:00 p.m.—First round women's tennis singles.

Tuesday, June 21

1:00 p.m.—18 holes match-play finals for lowest net score of 36 holes, Lee-trophy events. First round of 16 players for match-play Mershon-trophy events.

2:00 p.m.—Table-tennis tournament—men and women.

2:00 p.m.—Second round men's tennis singles.

2:30 p.m.—Women's putting contest.

3:00 p.m.—Second round women's tennis singles.

4:00 p.m.—First round mixed tennis doubles.
First round men's tennis doubles.

7:30 p.m.—Informal dinner-dance at the Congressional Country Club.

Wednesday, June 22

1:00 p.m.—18 holes second round match play for Mershon trophy.

2:00 p.m.—Semi-finals men's tennis singles.

3:00 p.m.—Finals of women's tennis singles.
Semi-finals mixed tennis doubles.

4:00 p.m.—Semi-finals men's tennis doubles.

Thursday, June 23

9:00 a.m.—Semi-finals 18 holes match play for Mershon trophy.

1:00 p.m.—18-hole final for Mershon trophy.

2:00 p.m.—Finals men's tennis singles.
Finals mixed tennis singles.
Finals mixed tennis doubles.

The golf greens fee is $2.00 per day. The charge for use of tennis court is 50¢ per day. Further details of the sports program will be included in a pamphlet available on registration at the convention.

Washington Beckons Summer Conventioneers

Some of the attractions in and near the Nation's Capital, scene of the AIEE 1938 summer convention

(Above) The Congressional Country Club where the sports events and entertainment features of the summer convention will center

(Top) Home of the first president of the United States at Mount Vernon, Va. © H. H. Rideout

(Middle) Tomb of Unknown Soldier and Amphitheater, Arlington Cemetery © H. H. Rideout

(Bottom) Supreme Court Building © Harris and Ewing

(Center) The Capitol and some of its beautiful grounds Photo by R. E. Williams (A'35)

(Bottom) George Washington Masonic Memorial © H. H. Rideout

Notice of Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held at the Mayflower Hotel, Washington, D. C., at 10 a.m. on Monday, June 20, 1938. This will constitute one session of the annual summer convention which is to be held this year in that city.

At this meeting, the annual report of the board of directors, and the reports of the committee of tellers on the ballots cast for the election of officers and for constitutional amendments will be presented.

Such other business, if any, as properly may come before the annual business meeting may be considered.

(Signed) H. H. HENLINE
National Secretary

The entertainment committee has provided, in addition to the usual program of a dinner-dance at the Congressional Country Club on Tuesday evening, a tea at Burgundy Farm, Alexandria, Va., on Wednesday afternoon and a final social gathering of the convention, a formal dinner on Thursday evening, which will be the occasion of the presentation of the Gaston Planté Medal to Doctor George W. Vinal by the French Ambassador and the award of prizes for the sports events.

WOMEN'S ENTERTAINMENT

In addition to the entertainment features included in the schedule of events, the women's entertainment committee has arranged an attractive program, including visits to places of interest in Washington, a bridge-luncheon at the Congressional Country Club preceding the dinner-dance held at the club in the evening, and a tea at Burgundy Farm in nearby Virginia. The women of the local Section will provide transportation and personally conduct individual tours that the visiting women may wish to take.

ADVANCE REGISTRATION

Members who will attend the convention are urged to register in advance by promptly returning the addressed advance-registration card, which they will receive by mail. This will be helpful to the committees and will permit badges to be made ready in advance, thus avoiding congestion at the registration desk.

A registration fee of $2.00 will be charged all nonmembers, except Enrolled Students and the immediate families of members.

HOTEL RESERVATIONS

All members planning to attend the convention should make their own hotel reservations, and the committee urges that this be done well in advance. The Mayflower, the convention headquarters hotel, has guaranteed reservations for 150 single rooms, 100 double rooms with double bed, and 250 double rooms with twin beds; but in order to be sure of desired accommodations, members planning to make reservation at the Mayflower should likewise make such reservation well in advance. A list of the principal hotels in Washington and their rates (European plan) for single and double rooms is given in an accompanying tabulation.

All downtown hotels are within a five- to ten-minute ride from convention headquarters. The hotels in the Capitol Plaza area and in the residential area are within a 10- to 20-minute ride from convention headquarters.

The personnel of the 1938 summer convention committee is as follows: General committee—William McClellan, *honorary chairman:* H. W. Osgood, *chairman;* C. A. Robinson, *vice-chairman;* G. L. Weller, *secretary;* A. F. E. Horn, *treasurer;* F. A. Allner, R. C. Bailey, L. D. Bliss, J. V. B. Duer, N. E. Funk, W. B. Kouwenhoven, T. J. MacKavanagh, J. F. Meyer, J. S. Miller, H. S. Osborne, H. M. Southgate, and W. H. Timbie. Chairmen of subcommittees—Roland Whitehurst, *finance;* J. H. Stephens, *transportation;* W. J. Ellenberger, *registration and housing;* H. E. Way, *publicity;* A. O. White, *sports;* R. W. Prince, *inspection trips;* F. M. Defandorf, *technical programs;* S. K. Brown *entertainment;* and R. C. Marshall, Jr., *women's entertainment.*

Final Announcement for the Lenox Meeting

All is in readiness for the three-day meeting of the North Eastern District of the AIEE to be held at Lenox, Mass., May 18–20, 1938, with headquarters in the Curtis Hotel. A splendid program of entertainment, technical sessions, and inspection trips to nearby industries awaits those who will attend. Those planning to attend who have not already registered in advance, are urged to fill in and mail the advance registration card or write to L. G. Hamilton, chairman, hotel and registration committee, care of central station Department, General Electric Company, 100 Woodlawn Ave., Pittsfield, Mass.

A more complete announcement of the meeting, including information on the various features—entertainment, inspection trips, and the technical program—was published in the April issue, pages 176–7. Since then the following supplementary information in regard to the stag smoker and the speakers for the general session and the banquet has been made available.

STAG SMOKER

The stag smoker at the Town Hall in Lenox on Wednesday evening, May 18, will be a very informal get-together and will include games, music, and entertainment probably by members of the General Electric Pittsfield works. It is requested that the men attending the meeting be prepared to take part in some good fun and, if convenient, bring along some old clothes. Should this be too inconvenient for some coming from out of town the entertainment committee may provide several old coats and other garments for those who are really interested. Another suggested alternative is to come without collars and neckties, in shirt sleeves, or in any manner which will emphasize the effect desired. There will be some competition between those with unusual costumes and all in all an evening of good fun and fellowship.

SPEAKERS

For the general session on Thursday morning, May 19, two speakers have been engaged. Roger Babson will address the meeting probably on some economic subject; he is the founder and now president and chairman of the board of Babson's Statistical Organization, Wellesley Hills, Mass., and is a well-known lecturer on statistical and economic subjects. K. K. Darrow (A'19) research physicist of the Bell Telephone Laboratories, Inc., New York, N. Y., will give an address on natural and artificial radioactivity. Doctor Darrow is noted for his many writings and lectures on physical subjects; full text of his address appears elsewhere in this issue. The speaker for the mixed banquet on Thursday evening, May 19, will be W. H. Timbie (A'10, F'24) professor of electrical engineering at Massachusetts Institute of Technology, Cambridge. Professor Timbie is a past vice-president of the AIEE and is currently chairman of the Institute's Sections committee.

Future AIEE Meetings

North Eastern District Meeting
Lenox, Mass. (Pittsfield Section)
May 18–20, 1938

Summer Convention
Washington, D. C., June 20–24, 1938

Pacific Coast Convention
Portland, Ore., August 9–12, 1938

Southern District Meeting
Miami, Fla., November 1938

Winter Convention
New York, N. Y., January 23–27, 1939

South West District Meeting
Houston, Texas, Spring, 1939

AIEE to Be Represented at Glasgow Congress

To represent the AIEE at the International Engineering Congress to be held at Glasgow, Scotland, June 21–24, 1938, A. P. M. Fleming (M'14, F'34) local honorary secretary of the AIEE, Manchester, England, and L. F. Morehouse (M'16, F'20) of London, have been appointed. The congress is being held in the conference hall of the Empire Exhibition, Scotland, 1938, which is scheduled to be open from May to October, and which includes a palace of engineering covering an area of five and one-half acres.

A program of technical sessions, inspection trips to various industries, excursions, and social events has been arranged. Technical sessions will be held during the mornings of June 21 and 22 and will include a series of 15 addresses by outstanding British and other engineers dealing with various branches of engineering; the congress will sit in three simultaneous sessions for these addresses. Membership of the congress is open to members of any recognized technical society.

AIEE Executive Committee Meets at Headquarters

A meeting of the executive committee of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., March 29, 1938, in place of the regular meeting of the board of directors.

Present: President W. H. Harrison (chairman), O. B. Blackwell, F. M. Farmer, C. R. Jones, A. M. MacCutcheon, W. I. Slichter, A. C. Stevens, members of the committee; C. R. Beardsley, director; H. H. Henline, national secretary.

Executive committee action on applications as of February 21, 1938, was reported as follows: two applicants transferred to the grade of Fellow; seven applicants transferred and 13 elected to the grade of Member; 43 applicants elected to the grade of Associate; 72 Students enrolled.

Reports were presented and approved of meetings of the board of examiners held February 17 and March 17, 1938. Upon recommendation of the board of examiners, the following actions were taken: eight applicants were transferred and 12 were elected to the grade of Member; 78 applicants were elected to the grade of Associate; 172 Students were enrolled.

The finance committee reported monthly disbursements amounting to $20,297.71 in February and $24,284.21 in March; report approved.

Recommendations of the finance committee, based on recommendations of the investment counsel of the Institute, concerning changes in the Institute's securities, were accepted and referred to the board of directors for letter ballot.

Approval was given to the holding of a joint session with the Institute of Radio Engineers during the AIEE Pacific Coast convention, in Portland, Ore., August 9–12, 1938.

Location and dates for the 1939 combined summer and Pacific Coast conventions were approved, as follows: Fairmont Hotel, San Francisco, Calif., June 26–30.

Report was made of the appointment of R. T. Henry as chairman of the standards committee's subcommittee on standardization of bushings.

The following recommendations of the standards committee were approved: (1) that the AIEE relinquish proprietary sponsorship of the committee on storage batteries—C40, with the understanding that it will be transferred to sectional committee procedure under American Standards Association and with AIEE sponsorship; (2) that the revised draft, prepared by the committee on protective devices, of the AIEE standard on oil circuit breakers be approved and printed as an Institute standard, it being understood that this standard then will be submitted to ASA for inclusion in a proposed American standard for oil circuit breakers under preparation by an ASA sectional committee on power switchgear.

Other subjects were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

Membership—

Mr. Institute Member:

Certainly, all of us appreciate the value of the work the Institute is doing to advance the profession of electrical engineering but only a few seem to realize that, as members, we also have an obligation to assist the Institute in improving its value to us. We can render this assistance through our help in securing new members; a larger membership naturally makes the Institute more representative of the profession, and incidentally permits increased and more forceful activities which benefit all of its members.

The Boy Scouts of America have a motto: "Do a good deed daily." It would be well if we adopted a similar motto, having a slight degree of retardation: "Get a new member yearly." Think what a force the Institute could be if we had 29,000 members instead of 14,500.

Be a good scout and give your membership committee just a little help.

E. T. Guenther

Vice-Chairman, District No. 7,
National Membership Committee

A membership proposal form appears on page 20 of the advertising section of this issue

Pacific Coast Convention to Have Session With IRE

Following last year's successful innovation, a joint technical session with the Pacific Coast members of the Institute of Radio Engineers is being planned as one of the features of the AIEE 1938 Pacific Coast convention to be held in Portland, Ore., August 9–12, 1938. Approval of the joint session was given by the AIEE executive committee at its meeting of March 29.

As announced previously, the dates for the 1938 convention are almost a month earlier than in previous recent years so as to provide a better opportunity for those planning combined vacation-convention trips. Portland is in the heart of the Pacific Northwest with its many scenic attractions, and is within fairly easy reach of some of the national parks. Another attraction will be an inspection trip to the Bonneville navigation and hydroelectric project with its famous fish ladder. Details of the program will be announced in subsequent issues.

1938 AIEE Year Book Is Now Available

In accordance with the provisions of the Institute's 1937–38 budget as approved by the finance committee and the board of directors, the 1938 edition of the AIEE Year Book has been issued, in limited edition, and is available to members of the Institute who have use for it. The book contains essentially the same material as was included in the 1937 edition; business and mailing addresses have been corrected as of February 28, 1938.

In keeping with established custom, copies of the Year Book have been distributed to all national, District, and Section officers, to Student Branch counselors, and to all members of all national committees. Other members wishing to secure a copy may do so by writing to the AIEE order department, 33 West 39th Street, New York, N. Y., giving correct mailing addresses.

The Year Book is not available to nonmembers of the Institute, nor is its use permitted for commercial, promotional, or other circularization purposes.

New York Section Group Inspects the "Lord Kelvin"

On March 28, 1938, 312 members of the communication group of the AIEE New York Section inspected the Western Union cable-repair ship "Lord Kelvin" while it was in port to load a 4,200-foot chain to be used for towing a submarine-cable plow (see article elsewhere in this issue). The accompanying illustration shows a group of visitors inspecting the equipment on the foredeck.

Fluorescent Tubular Lamps Soon to Be Available

At a joint meeting of the New York Electrical Society and the New York Sections of the Illuminating Engineering Society and the AIEE, held in New York, N. Y., April 21, 1938, new fluorescent light sources were described and their early commercial availability was announced. Speakers at the meeting were Ward Harrison (F'36) director of engineering, General Electric Company, Nela Park, Cleveland, Ohio, and S. G. Hibben (A'34) director of applied lighting, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J. The laboratory development of these lamps was announced about two years ago (*EE May '36, p. 560*).

The new lamps, which are designated "fluorescent lumiline lamps," provide light of almost any color or tint at efficiencies much higher than those at which colored light may be obtained from incandescent lamps. In physical appearance and dimensions, the lamps are similar to the present incandescent "lumiline" lamps, but are entirely different in their operation. Specially compounded and heat-treated powders are applied to the insides of the tubes. These powders fluoresce when activated by ultraviolet radiation, reradiating the ultraviolet energy in the form of visible radiation. The ultraviolet radiation in the lamp is produced by a trace of mercury and a small amount of argon gas at low pressure.

Each fluorescent powder has its own characteristic wave band with which it responds to ultraviolet radiation, thus forming its own particular color of emitted light. By the proper selection and blending of powders it is possible to produce light of practically any color or tint. The efficiencies of the lamps are much greater than those of colored incandescent lamps, but vary within fairly wide limits. For example, the green lamp has been found to be most efficient, producing 60 lumens per watt in the 30-watt size; blue is least efficient, producing about 20 lumens per watt; white light is produced at about 30 lumens per watt. The 20 lumens per watt of the blue lamp compares with 0.3 lumen per watt of the blue incandescent lamp. The light from the "daylight" fluorescent lamp is said to be the nearest approach to natural daylight that has ever been produced by an artificial illuminant, the color temperature closely approximating 6,500 degrees Kelvin.

Like all gaseous-conductor lamps, the fluorescent lamps require special transformers; they attain full brilliancy in a few seconds. A wide field of application for these lamps is predicted. At present they will be available in 15-, 20-, and 30-watt sizes the length of these being, respectively, 18, 24, and 36 inches, with tube diameters of one inch for the 15- and 20-watt sizes and one and one half inch for the 30-watt size.

Hydroelectric Power in Washington. Part V (Bulletin No. 95) of a series of bulletins on hydroelectric power in the state of Washington recently has been published by the engineering experiment station of the University of Washington. This part, a bibliography of technical papers relating to hydroelectric developments in Washington, supplements a previous bibliographic bulletin published in 1926, listing all generally available technical papers published during the ten-year period 1926–36. The complete list of bulletins in this survey, all compiled by C. E. Magnusson (A'05, F'13) professor of electrical engineering and director of the engineering experiment station at the university, is as follows:

Part I (Bulletin No. 26)—A Reconnaissance Survey, 1924.

Part II (Bulletin No. 36)—A Bibliography of Technical Papers, 1926.

Part III (Bulletin No. 78)—A Brief on Proposed Grand Coulee Dams, 1935.

Part IV (Bulletin No. 90)—Regional Electric-Power Transmission. The Grid System, 1936.

Part V (Bulletin No. 95)—A Bibliography of Technical Papers, (1926–36), 1937.

Part VI (Bulletin No. 96)—International Boundary Waters, 1937.

Requests for bulletins and reports should be addressed to the Director, Engineering Experiment Station, University of Washington, Seattle.

New Heating and Ventilating Guide. The Heating, Ventilating, Air Conditioning Guide 1938, 16th edition of the official reference book compiled by the American Society of Heating and Ventilating Engineers, was published recently. The 1938 edition contains 840 pages of technical reference data included in 45 chapters covering material on design and specifications of heating, ventilating, and air-conditioning systems. It contains new material on the cooling phases of air-conditioning practice, with revised chapters on refrigerants and air-drying agents, cooling-load determinations, and design of central systems for cooling and dehumidifying. A chapter on air conditioning in the treatment of disease appears for the first time. A new feature of the book is a visual chapter index. In addition to the technical material, over 300 pages of manufacturers catalog data are included, as well as an index to modern equipment listing 300 items, cross-indexed as to product and manufacturer. A complete listing of society members, including their professional or business affiliations, forms a separate section. Approximately 100 different experts assisted the guide publication committee of the society in compiling the 1938 volume. Single copies of the guide are available at $5 from the society headquarters, 51 Madison Ave., New York, N. Y.

Testing and Application of Lightning Arresters

For some time information dealing with the testing and application of lightning arresters has been needed. To provide such information, two memoranda entitled "General Guide for Utilities on Methods of Testing Lightning Arresters" and "Factors Affecting Application of Arresters" have been prepared by the lightning arrester subcommittee of the AIEE committee on protective devices.

The memorandum on the testing of lightning arresters describes three suitable circuits for making 60-cycle tests, suggests a simple test procedure, and provides information that will assist in the interpretation of test results. The memorandum on the application of arresters discusses the factors that should be given consideration in the selection of ratings of surge protective devices. The various types of lightning arrester connections used for distribution-transformer installations also are described, and a simplified method of identification for the various types of interconnections is suggested.

Advance copies of "Testing and Application of Lightning Arresters," AIEE Technical Paper No. 38-43, which contains both memoranda, have been made available because the paper will be scheduled on the program of the 1938 Pacific Coast convention. Copies may be obtained by mail by addressing the AIEE order department and enclosing remittance of 10¢ per copy; if purchased at headquarters, the price is 5¢ per copy.

New York Power Group Awards Paper Prizes

For several years, one of the annual meetings held by the power group of the AIEE New York Section has been a "volunteer paper program" consisting entirely of papers selected from voluntary submissions. This year, for the first time, two cash prizes were awarded. The meeting, which was held April 14, 1938 in the Engineering Societies Building, was attended by about 150 members and guests.

From the nine papers submitted for consideration, the following four were presented:

Brush Economics, **K. B. Hoffman** (A'34) Consolidated Edison Company of New York, Inc.

An Enclosed Improved Network-Protector Fuse, **Woodman Perine** (A'35) Consolidated Edison Company of New York, Inc.

Selecting Proper Size of Electrical Wire and Cable, **Ludwig F. Roehmann** (M'37) Anaconda Wire and Cable Company.

Shunt Capacitors for Distribution Circuits, **Peter White** (A'37) Phoenix Engineering Corporation.

All four authors were coached by the instructor of the public-speaking courses conducted by the Section; 15 minutes was allowed for the presentation of each paper.

First prize of $50 was awarded to Mr. Perine; second prize of $25 to Mr. Hoffman. Judges of the contest were R. E. Powers (A'33) engineering manager, eastern district, Westinghouse Electric and Manufacturing Company; W. I. Slichter (A'00 F'12, national treasurer), professor of electrical engineering, Columbia University; and Philip Sporn (A'20, F'30) vice-president and chief engineer, American Gas and Electric Service Corporation.

Student Conference Held at VMI

A total of 172 students in electrical engineering and Student Branch counselors registered at the annual student conference of the AIEE Southern District, held at the Virginia Military Institute, March 24–26. Representatives were present from every one of the 18 Branches in the District:

Alabama Polytechnic Institute, Auburn, Ala.
University of Alabama, University, Ala.
Clemson Agricultural College, Clemson, S. C.
Duke University, Durham, N. C.
University of Florida, Gainesville, Fla.
Georgia School of Technology, Atlanta, Ga.
University of Kentucky, Lexington, Ky.
Louisiana State University, Baton Rouge, La.
University of Louisville, Louisville, Ky.
Mississippi State College, State College, Miss.
North Carolina State College, Raleigh, N. C.
University of North Carolina, Chapel Hill, N. C.
University of South Carolina, Columbia, S. C.
University of Tennessee, Knoxville, Tenn.
Tulane University, New Orleans, La.
Virginia Military Institute, Lexington, Va.
Virginia Polytechnic Institute, Blacksburg, Va.
University of Virginia, University, Va.

The only scheduled activity on Thursday, March 24, was an informal smoker given by the VMI Student Branch. A number of visitors arrived in time to visit neighboring points of historic interest and scenic beauty.

Six student papers were presented at the technical session on Friday morning, March 25:

Use of Neon Lamps to Indicate Corona Loss, **Edward G. Outlaw,** University of North Carolina.

Voltage Regulation of Alternating-Current Transformers, **Harry B. Brown,** Alabama Polytechnic Institute.

An Optical Tachometer, **J. Robert Rombach, Jr.,** Tulane University.

Electrically Generated Supersonic Waves, **Raymond G. Tessmer,** Virginia Polytechnic Institute.

Construction of an Induction Furnace, **W. M. Furlow, Jr.,** Georgia School of Technology.

The Application of Symmetrical Components to Protective Relaying, **Louis A. King,** University of Tennessee.

The first prize was awarded to L. A. King and the second to J. R. Rombach. E. G. Outlaw and R. G. Tessmer tied for third place. The prizes were $15, $10, and two of $5.

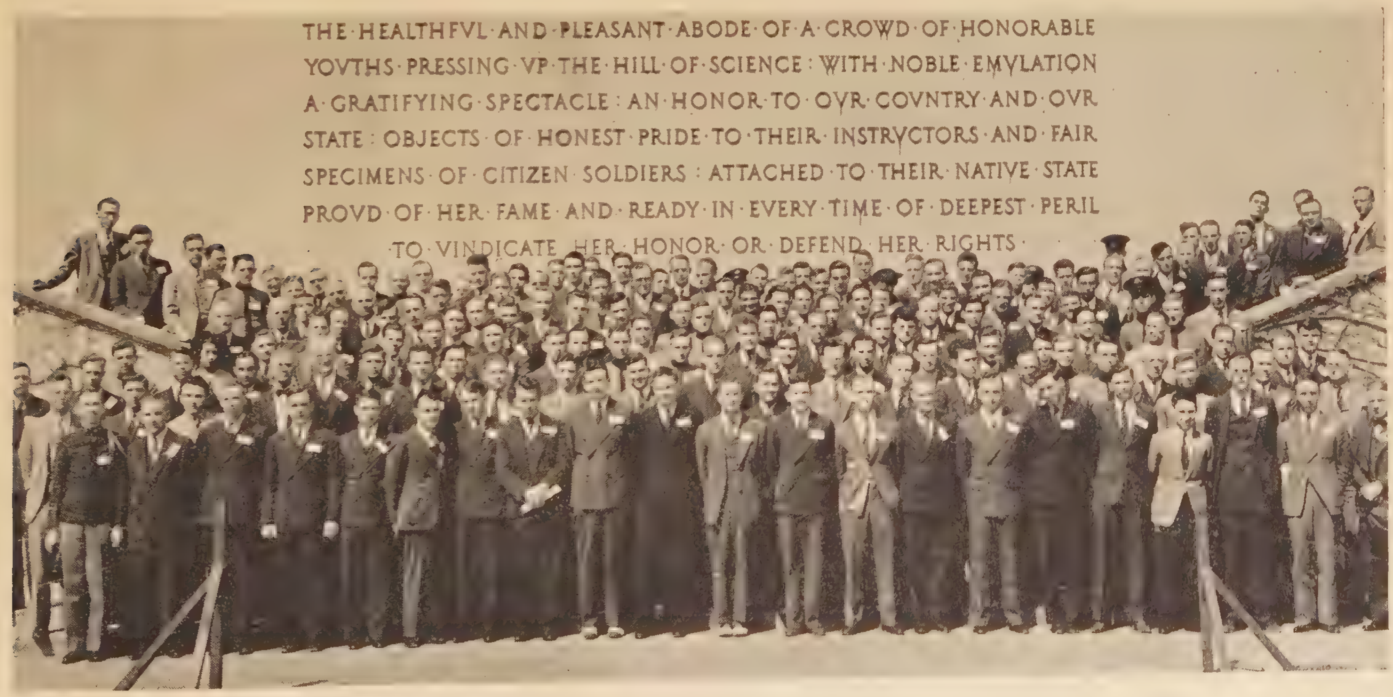
A business session was held Friday afternoon. It was decided that the next student conference of the Southern District would be held in Miami, Fla. in conjunction with the AIEE Southern District meeting. Professor E. F. Smith of the University of Florida was unanimously elected chairman of the District committee on student activities and was designated to represent the committee at the next summer convention.

A military review was held in honor of the visitors. The infantry companies, the cavalry troop, and the field artillery battery made an inspiring picture.

The attendance at the annual dinner was 191. The principal speaker of the evening was Doctor Dugald C. Jackson, past-president of the AIEE. Others on the program were Edwin D. Wood, AIEE vice-president, and H. H. Henline, national secretary.

A dance, called the AIEE Ball, was given by the corps of cadets Friday evening, and all conference visitors were invited.

Publication on Photoelasticity. "Photoelastic Journal" edited by A. G. Solakian at 55 West 42d Street, New York, N. Y., recently made its appearance with volume 1, number 1, issued under date of January 1938. Stating that it will concern itself with stress, polarized light, and plastics, this periodical sets itself the following objectives: "(1) To make photoelastic method of stress analysis simple in principle, practical in application, and popular in use; (2) to develop photoelastic research with a view of applying it to the economic and safe design of machine and structural elements; (3) to develop a close contact and co-operation between photoelasticians and industrial organizations; (4) to keep the reader informed with up-to-date developments of photoelasticity and relative subjects here and abroad; (5) to make photoelasticity accessible to a larger group of students, teachers, researchers, practicing engineers, educational and industrial organizations, etc."


THE·HEALTHFVL·AND·PLEASANT·ABODE·OF·A·CROWD·OF·HONORABLE
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PROVD·OF·HER·FAME·AND·READY·IN·EVERY·TIME·OF·DEEPEST·PERIL
TO·VINDICATE·HER·HONOR·OR·DEFEND·HER·RIGHTS·

A group of those that attended the Southern District Student Branch conference at Virginia Military Institute

Annual Economics Conference. Sponsored jointly by Stevens Institute of Technology and the Society for the Advancement of Management, the Eighth Annual Economics Conference for Engineers is scheduled to be held at the Stevens Engineering Camp, Johnsonburg, N. J., from June 24 to July 2. The conference group will be divided into six sections on motion and time study, human relations, marketing, industrial management, and management problems. Four daily sessions are scheduled for each of the six sections, and one section will serve as a round table for teachers of management. Afternoons will be devoted to informal conferences and recreation, and each evening a prominent speaker will address the conference. Information may be secured from Professor G. W. Barnwell, director of the 1938 conference, Stevens Institute of Technology, Hoboken, N. J.

Future Meetings of Other Societies

American Association for the Advancement of Science. Summer meeting, June 27–July 2, Ottawa, Can.

American Iron and Steel Institute. General meeting, May 26, New York, N. Y.

American Physical Society. 221st meeting, June 22–24, 1938, Pacific Coast section in affiliation with AAAS, San Diego, Calif.
222d meeting, June 24–25, Toronto, Ont., Can.

American Society for Testing Materials. Annual meeting, June 27–July 1, Atlantic City, N. J.

American Society of Civil Engineers. Annual convention, July 20–22, Salt Lake City, Utah.

American Society of Mechanical Engineers, Semiannual meeting, June 20–24, St. Louis, Mo.

Canadian Electrical Association. Annual convention, June 22–24, Seigniory Club, Province of Quebec, Can.

Edison Electric Institute. Annual convention, June 6–9, Atlantic City, N. J.

Illuminating Engineering Society. Annual convention, Aug. 29–Sept. 1, Minneapolis, Minn.

Institute of Radio Engineers. Annual convention, June 16–18, New York, N. Y.

International Conference of Naval Architects and Marine Engineers. June 16–18, London, England.

International Engineering Congress. June 21–24, Glasgow, Scotland.

National Electrical Manufacturers Association. Spring conference, May 15–20, Hot Springs, Va.

Pacific Coast Electrical Association. Annual convention, May 26–27, San Francisco, Calif.

Society of Automotive Engineers. Annual meeting, June 12–17, White Sulphur Springs, W. Va.

Society of Chemical Industry. Annual meeting, June 20–22, Ottawa, Can.

Society of Naval Architects and Marine Engineers. Spring meeting, May 17, Washington, D. C.

Current Items From American Engineering Council

No Patent Legislation This Session of Congress

Congressman McFarlane and his associates have substituted H.R. 10068 for H.R. 9259 and thus changed many of the implications of current patent legislation. Moreover, Council's staff reliably is informed that no compulsory licensing of patents or similar threat to change patent regulations radically is in the schedule of bills to come up for action during this session of Congress. In fact, proponents of such legislation are no longer in a mood to fight for it.

Congressman McFarlane's new bill, H.R. 10068, simply proposes to amend section 35 of the revised statutes to provide for compulsory license where there is satisfactory evidence that a patent is not being used after the expiration of five years from date of issuance. In other words, the inventor would have an absolutely exclusive right to his patent for five years, but would have to put it into use within a period of five years to maintain all of the rights originally granted under his patent to the exclusive use of his invention or discovery.

As a basis for the equitable determination of royalties where licenses might be ordered under this revision of the statute, provision is made for filing an itemized statement with applications for patents setting forth the time and expense devoted to the development of the patent together with an appraisal of the intrinsic value of the invention or discovery, in so far as such an estimate is possible at that time.

Program for 1938 Includes Five Groups of Activities

As an outgrowth of the discussions and recommendations of the 1938 annual meeting of the AEC assembly held during January, the AEC executive committee has approved the following program for 1938.

With determination to use all resources at its command, most effectively, the management of the American Engineering Council has surveyed the field of its opportunities for 1938 and selected five groups of activities as being most likely to serve useful purposes among members of member organizations and the general public in the immediate future. They constitute a program which may tax Council's facilities, but they conform to the wishes of our assembly and executive committee; and a part of the program is already being translated into action.

I. Public-Affairs' Function

Serving through its staff and committees, as an interprofessional instrumentality for the presentation of the engineers' viewpoint on all phases of public affairs where engineering knowledge and experience are involved and the considered opinion of the engineering profession may be of public service, the American Engineering Council will:

1. Upon request, transmit engineering opinion and factual information to the Federal Government, including both legislative and administrative branches.

2. Make unbiased interpretations for the engineering profession of Federal laws, rules, regulations, and practices and report them through its publications and releases.

II. Public-Discussion Function

In co-operation with member societies, the American Engineering Council is initiating the practice of holding forums in which public problems related to engineering will be discussed by engineers for the purpose of clarifying and co-ordinating engineers' opinions. Initial forums are being arranged in eastern cities. Experience with the earlier forums will determine the expansion of the public discussion function toward a broader consideration of public problems.

III. Engineers'-Embassy Function

The staff of the American Engineering Council will continue to render as much service as possible under existing circumstances to member societies and their individual members on matters related to engineering arising from or connected with the Federal Government and its several branches.

IV. Publicity Function

The results of the functions outlined above are to be reported regularly to member organizations. In fact, within the limitations of funds, personnel and facilities, the American Engineering Council is increasing the volume of its publications and endeavoring to improve their effectiveness. The schedule for 1938 includes:

1. A change in title, appearance and editorial policy in Council's monthly publication.

2. A greater number of releases to member societies including their editors and boards of direction, and to the "press" regarding Council's activities and observations.

3. Use of annotated bibliography of articles expressing engineering opinion on matters of broad interest to engineers as an aid in integrating the work of AEC with all phases of related professional engineering opinion.

V. Fact-Finding Function

The functions referred to above have been selected from the many useful services which the American Engineering Council might perform. Several others should have consideration. Of such possibilities, the following have been selected for attention, if time permits, and if additional financing can be secured for such activities:

1. A fact-finding investigation of the situation surrounding employment of engineers and the

relation to their employment of unionization and registration. In the meantime, Council will continue actively to support the merit system in public service under civil service, and in its conferences with government officials Council will endeavor to have them avoid unnecessary government competition with engineers in private practice.

2. A survey to determine the effect on employment of technology. As opportunities present themselves, Council will continue to crystallize public opinion of research, invention, and scientific investigation into appreciation of the true value of the broad field of technology as an entirely practical means for opening up new frontiers of employment and new sources of wealth essential to the attainment of that higher standard of living, which has become generally accepted as the next major advance in our civilization.

3. A study of the relation of engineering to economics in public questions involving the capital goods, construction, extractive, and process industries in which engineers play the double role of being technically associated as employees and functionally related as managers of enterprises. The controlling factor is likely to be financing, but it is believed that influential members of member societies may be able to aid Council in interesting some of the foundations.

In carrying out this program, in 1938, the American Engineering Council will continue to be guided by consideration of the public interest and the enlargement of public understanding of the professional responsibility of the engineer in the United States. Neither officers, staff nor the committees will lose any opportunity to serve the engineering profession and more particularly members of member societies as a clearing house for factual information regarding the engineers' economic status in private practice or as an employee of public and private enterprise.

William McClellan
President

Frederick M. Feiker
Executive Secretary

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. Electrical Engineering will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or reject them entirely.

ALL letters submitted for consideration should be the original typewritten copy, double spaced. Any illustrations submitted should be in duplicate, one copy to be an inked drawing but without lettering, and other to be lettered. Captions should be furnished for all illustrations.

STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Cable and Damper Vibration Studies

To the Editor:

In the article "Cable and Damper Vibration Studies," published in Electrical Engineering, June 1936, pages 600–14, L. A. Pipes develops a mathematical method of calculating the damping action of vibration-free cables (see also International High-Tension Conference 1935 Report No. 128). The results of this calculation do not agree with actual practice. From this fact it may be assumed that the assumptions which L. A. Pipes found it necessary to use in order to make the difficult problem mathematically possible are wrong.

The fact is that the vibration-free cables proposed by me actually do not vibrate. These cables of a total length of 44,000 meters (1936) have been tested by special experimental devices in practical use for more than two years and only an occasional slight clicking can be heard.

A short time ago a cable of 600 meters length, which had been operating for 14 months on a test span, was taken down for examination. A control cable of ordinary construction was erected parallel to the special cable. The standard cable vibrated about two-thirds of the time; the special cable was completely motionless.

The special cable was then cut to pieces and thoroughly examined for signs of abrasion. Effective magnification revealed no such signs on the individual wires. The zinc galvanizing of the cable core was entirely intact. This was proved by means of the well-known test of dipping the cable into a solution of copper sulphate. Because of the very small play, deformations and abrasions are impossible. Experience should be more convincing than opinions, even if commonly held.

In damping systems it is not the question of suppressing and counteracting existing vibrations, but rather that of preventing vibrations at their source. Let us therefore study the causes.

It is generally known that eddy currents of the wind are responsible for the initiation of vibrations. These eddy currents, when the wind is blowing, break loose behind the cable more or less perpendicularly to the direction of the conductor and give to the cable impulses which are vertical for horizontal winds. These act on the cable alternately in the upward and downward directions. The frequencies of these impulses have some relation to the velocity of the wind. If the frequencies of these impulses correspond with the natural frequency or are higher harmonics of the natural frequency of the cable, a vibration may arise in it. In addition to this it is necessary that the release of the air eddies scattered arbitrarily over the length of the cable be brought into a certain order, namely, they must be forced by some means to give their impulses to the cable at the right moment and at the right spot in order to initiate vibration. In the same way in a steam engine it is not sufficient to have the steam enter under pressure into the cylinder in order to get the reciprocal motion of the piston. The release of the eddy currents has to be controlled if they are to initiate the vibration of the cable. This control is performed by the movements of the cable. If accidentally on account of adjustments of supports due to temperature changes, or if incidentally on a certain length of the cable the initiation of eddy currents take place simultaneously and in a suitable sense or direction so that the impulse is strong enough to move the cable just a little bit, then there arises a traveling wave which runs in two or more directions at the velocity of propagation of waves. The movement of the cable prematurely frees the eddies which are poised or otherwise ready, and these eddies in their turn give their impulses to the cable. In this way the traveling wave grows larger. From the point of origin, other traveling waves, with the frequencies of the first eddies, will follow and loosen more and more eddies prematurely and co-ordinate them into the system. By the movement of the cable the freeing of eddy currents is controlled in such a way that they always give their impulses to the cable at the right moment. In this manner only is the arising of a vibration possible.

This theory explains an observation, namely, that all the cables of a line do not start vibrating at the same time. In case the cables are motionless, then a sufficient number of eddies to arouse a traveling wave sufficiently strong to control the other eddies has not been initiated. If such a cable is given a little shock, as mentioned above, a real vibration arises.

This explanation seems necessary in order to prove that a damping of vibrations can only be successful if the initiating of movements of the cable can be suppressed. In the proposed vibration-free cable, small traveling waves are suppressed in a short time. The damping effect of the cable construction is more powerful than that energy released from the air eddies. Therefore, in this cable, the amplitude of a traveling wave does not increase; rather it diminishes, and the wave very soon disappears completely.

In the vibration-free cable, the hollow cable and the core cable have such tensions that they try to take different catenary curves. (These facts were pointed out in a report, No. 128, of the International High-Tension Conference, Paris, 1935.) The hollow cable lies upon the core cable with only a part of its weight. Due to the traveling wave, the hollow cable lifts itself off the core cable when the force resulting from the mass of the hollow cable and the acceleration of the motion is stronger for the small sections of the cable than the pressure of the hollow cable, due to its weight, upon the core. The lifting off and falling back of the two cables results in damping, which may be explained by the absorption of energy and by disturbances in the velocity of propagation of waves.

These considerations explain why, in the construction and in the mathematical analysis of vibration-free cables and damping systems, the starting point cannot be the fact that the cables are already vibrating and that these vibrations have to be damped. It must rather be the fact that there must not arise any vibrations at all. The best construction is that which suppresses the initial movement of the cable. Having eliminated the larger vibrations, the movement of the two parts of the vibration-free cable against one another is very weak and occurs very seldom. This is the reason why there is absolutely no destructive effect observed.

Besides these merely theoretical arguments, the satisfactory results of the tests with vibration-free cable on lines in use prove our expectations were right. Today the vibration-free cable is no longer a merely theoretical proposition, as Mr. Pipes writes in his article, but a thoroughly tested construction in the use of which difficulties are not now expected. In Germany, a new 100-kv line 56 kilometers long is now to be equipped with vibration-free cable. The installation is based on the entirely satisfactory results of the observations made on several existing lines of various lengths equipped with steel-aldrey and steel-aluminum cables.

The cables and installations are not much more expensive than for more standard conductors in use. There seems no reason why general use of vibration-free conductors cannot be expected.

Very truly yours,

MAX PREISWERK

(Chief Engineer, Société Anonyme pour l'Industrie de l'Aluminium, Neuhausen, Switzerland)

Registration of Engineers

To the Editor:

Actuated by the request for information on registration as made by Louis S. Leavitt (A'24, M'28) and published on page 42 or the January 1938 issue ELECTRICAL ENGINEERING, and noting the apparent need for enlightenment in this particular case, I offer the following facts for consideration.

I have had dealings with two state boards as well as the National Council of State Boards and have nothing but the highest praise for the efficient and entirely impersonal and ethical manner evidenced by these bodies.

Regarding Mr. Leavitt's guesses, predictions and humble opinions to the effect that registration will affect the profession adversely by degenerating into a political racket and lowering our ethics, I have seen no indications in any of my dealings with the various boards mentioned to substantiate such a viewpoint.

Regarding Mr. Leavitt's implications that it might be well to start a "backfire aimed at removing the law from the books," it seems to me that such words are rather hasty and uncalled for, especially in view of the prima-facie evidence of lack of information contained in his request for factual data.

It is, of course, regrettable that the profession should find dissension in its own ranks on this matter. Complete accord should be our aim if we are ever to achieve a status among the learned professions commensurate with our worth.

We lag considerably in respect to our professional status as evidenced by the lack of recognition accorded by the laity. This statement is borne out in one respect by the increasing indiscriminate use of the word "engineer."

As Mr. Leavitt points out, no factual data has been published in ELECTRICAL ENGINEERING regarding registration laws now in effect. I believe it would be well to inform the membership on these matters. It apparently seems to be vitally necessary.

Regarding our economic status, which has been so ably presented recently in ELECTRICAL ENGINEERING, I have always felt that it is more or less dependent on the establishment of our professional status. In other words, until the latter is definitely established, the former is bound to lag in direct proportion therewith.

On this premise, I have always welcomed any attempt to raise the professional standing of the engineering profession, and in consequence have of my own volition sought and obtained registration whether needed or not.

I have found over a period of 15 years, that registration has in no wise injured my professional standing in any respect, and that, on the contrary it has on several occasions been of inestimable assistance thereto.

Even though I do not happen to come under the requisite classification given by Mr. Leavitt of having "been *forced* to go over the hurdles in securing registration" and cannot classify this letter as a "brotherly act" I believe it contains the type of information which has been requested.

Sincerely yours,

C. SWAIN LUMLEY (A'23, M'29)

(Assistant Electrical Engineer, City of Detroit, Mich.)

Preparation of Manuscripts

To the Editor:

I read with pleasure your bulletin on "Preparation of Manuscripts" and I again take a jab at your policy of publishing as first and foremost school and college papers. I refer to the mathematical formula that invariably occupies first place in the journal. This is, no doubt, of interest to professors and some students but it is not a subject of interest to a substantial group of members. A lot of members may glow with pride that they should be considered interested in such mathematical fairy tales but such matter does not promote the engineering business of the country. As a country's prosperity depends entirely on business, and business depends on engineering, your magazine should devote itself to business material because the schools and colleges are already endowed.

I read further in your instruction that mathematical formulae should be given in an appendix when invariably it is the main part of the journal. Engineering is absent without business to support it. Some people claim that mathematical studies disclose new paths to follow. I think Michael Pupin's contributions are given as an example. I happen to know that Pupin filled several rooms with wires and spent hours of hard work to arrive at his solution. I was fortunate enough to pass integral calculus 100 per cent at Columbia under J. Howard Van Amringe. That is, he gave me a mark of 10. Probably I did not deserve it but it showed I was as good as the average in that day. Ever since then I have not had or could see any use for it in the engineering business world. The catenary was figured out long before I was born. It was just a mental exercise for me to do it. To continue training for a prize fight without ever holding the match seems silly to me.

It frankly gets my goat to see this psychic attitude in the AIEE journal. How about publishing this letter, or part of it, and see if you get any comments.

I also want to state right here that I read your explanations of electronics and how the atom is held together with a "nutron" [sic]. I want to go on record that I do not believe it.

Very truly yours,

C. J. HOLSLAG (M'19)

(President, Electric Arc Cutting and Welding Company, Newark, N. J.)

Electron Theory

To the Editor:

I was very much attracted by a paper appearing in the January issue of ELECTRICAL ENGINEERING entitled "Electron Theory." This paper is so outstandingly well written that I feel as though I should express my appreciation of it to you and its author, Professor R. G. Kloeffler of Kansas State College, Manhattan. It seems to me that the manner of presenting this article is much to be commended and should be taken as a model in writing many other technical papers.

Personally I have been much occupied in recent years with making a living and I had never taken up the study of electron tubes which seem destined to play an increasingly important part in our lives. Recently I have frequently felt the need of such knowledge and have consulted certain authorities. I was almost immediately plunged over my head in higher mathematics which I had not the desire nor the freshness of study to go into. The thing that makes Professor Kloeffler's article so very interesting and informative is that he has succeeded in explaining completely, a complicated and broad subject in such a way as entirely to omit mathematics but still make the subject plain to any one who will read it with concentration.

I think it is true that a very large number of men in our profession do not keep their mathematics in working order. Of course, a few do and there are some subjects that cannot be treated except at undue length without resort to mathematics and I have no quarrel with this form of presentation beyond the fact that I do not think it reaches any large number of readers.

I have long been an advocate of teaching and helping the technical man to a better form of expression than he now has and I think the article in question very fully carries into effect the ideal to which my thoughts have worked. It often seems a pity that men in possession of invaluable information to their own profession and to the public, as a general thing, are unable to impart it in such a way that it could be assimilated by other technicians and particularly by intelligent laymen.

Yours very truly,

ALBERT MILMOW (M'30)

(Sales Engineer, Charlotte, N. C.)

Personal Items

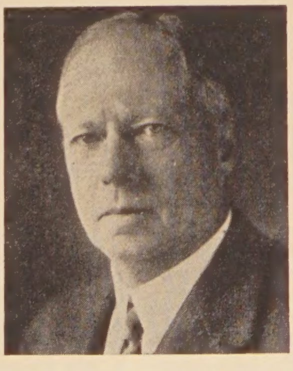
W. H. Harrison (A'20, F'31) has been elected vice-president and chief engineer of the American Telephone and Telegraph Company, New York, N. Y. Mr. Harrison, president of the Institute, formerly was assistant vice-president of the department of engineering and operation of the company. He was born June 11, 1892, at Brooklyn, N. Y., and was graduated in industrial electrical engineering at Pratt Institute in 1915. He entered the employ of the New York Telephone Company in 1909, where his work until 1915 included apparatus inspection, assembling, and wiring. From 1915 to 1919 he was engaged in telephone circuit design in the engineering department of the Western Electric Company, and in 1919 he became a member of the engineering staff of the American Telephone and Telegraph Company. In 1924 Mr. Harrison was made equipment and building engineer with general supervision of the engineering of the subscribers station and central office plant of the Bell telephone system, and in 1929 he became plant engineer, with broad responsibilities including general direction of the engineering, design, and layout of all departments of the Bell System plant; including system relations with other wire-using utilities. In 1933 Mr. Harrison was elected vice-president in charge of operations of the Bell Telephone Company of Pennsylvania and the Diamond State Telephone Company of Delaware, with headquarters in Philadelphia, Pa. He was appointed assistant vice-president in the department of operation and engineering and transferred to New York in 1937. Mr. Harrison has a long record of active service in the Institute. Besides being president, he is at present a member of the Edison Medal and Lamme Medal committees, and is the Institute's representative on the Charles A. Coffin Fellowship and Research Fund Committee, American Engineering Council, and the John Fritz Medal board of award. Within recent years he has served as member or chairman of several other technical and general committees of the Institute.

Bancroft Gherardi (A'95, F'12) has retired as vice-president and chief engineer of the American Telephone and Telegraph Company, New York, N. Y. Doctor Gherardi, a past-president of the Institute, has been associated with the American Telephone and Telegraph Company and its associated companies since 1895. He was born April 6, 1873, at San Francisco, Cal., and received the degree of bachelor of science in 1891 at the Polytechnic Institute of Brooklyn, N. Y.; in 1893 he received the degree of mechanical engineer, and in 1894 the master's degree in mechanical engineering at Cornell University. Worcester Polytechnic Institute granted to him the honorary degree of doctor of engineering in 1936. In 1895 Doctor Gherardi entered the employ of the New York (N. Y.) Telephone Company, where he was engaged in various problems in planning and supervision. Four years later he became engineer of the traffic department of that company, and in 1901 was appointed chief engineer of the New York and New Jersey Telephone Company. He was assistant chief engineer of the New York Telephone Company during 1906–07. Doctor Gherardi became engineer of plant for the American Telephone and Telegraph Company in 1907, holding that position until 1918, when he was appointed acting chief engineer. He was appointed chief engineer later in the same year, and for more than 17 years he was vice-president and chief engineer of the company. He is a director of several telephone companies. Doctor Gherardi has contributed generously to the work of the Institute, having served as a manager, 1905–08 and 1914–17; vice-president, 1908–10; and president, 1927–28. He has been a member of the committees on finance, headquarters, research, and the Edison Medal and executive committees. He was chairman of the committee on Institute policy (formerly public policy) from 1930 until 1933. He has served as a member of the board of directors of the American Standards Association, United Engineering Societies, United Engineering Societies Library Board; and as Institute representative on the National Research Council, United States National Committee of the International Electrotechnical Commission, John Fritz Medal board of award, and the Charles A. Coffin Fellowship and Research Fund Committee. Doctor Gherardi was awarded the Edison Medal of the AIEE in 1932 and is a member for life. In 1923 the Japanese Government conferred upon him the emblem of the Fourth Order of the Rising Sun. He is a member of several technical societies.

H. S. Warren (A'03, F'13) has retired as director of protection development of the Bell Telephone Laboratories, New York, N. Y., after more than 38 years of service in the Bell system, and has announced the opening of an engineering office in New York as consultant in electrical protection. Mr. Warren joined the engineering staff of the American Bell Telephone Company—which subsequently became the American Telephone and Telegraph Company—in Boston, in 1899. After being in charge of transmission development in Boston for several years he was transferred to New York in 1907 when the Boston laboratories were moved. He was appointed director of protection development in 1934, when the department of development and research of the American Telephone and Telegraph Company was merged with the Bell Telephone Laboratories. He has been a member of the Institute's committee on safety since 1915 (chairman, 1935–37) and a member of the committee on power transmission and distribution since 1925. Mr. Warren was a member of the committee on transportation during 1916–17; the Institute's alternate on the electrical committee of the National Fire Prevention Association, 1932–34; and representative on that committee during 1935–36. During 1935–36 he was also a member of the committee on low-voltage hazards of the National Safety Council and representative on the National Fire Waste Council.

Joseph Weil (A'24, F'36) has been appointed dean of the college of engineering and director of the engineering experiment station of the University of Florida, Gainesville. Dean Weil was born at Baltimore, Md., July 19, 1897, and received the degree of bachelor of science in engineering at The Johns Hopkins University in 1918; in 1926 he received the degree of master of science from the University of Pittsburgh. Following his graduation in 1918 he became research assistant for the United States Naval Consulting Board, later entering the employ of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He became a member of the faculty of the University of Florida in 1921, and was appointed successively instructor, assistant professor, associate professor, becoming professor and head of the department of electrical engineering in 1930. Besides teaching, Dean Weil has served as a consulting engineer for industrial organizations, several municipalities, the State of Florida, and various governmental agencies. He is also chief engineer of the State Radio Station WRUF and director of radio projects for the United States Works Progress Administration in Florida. He served as chairman of the AIEE Florida Section from its organization in 1931 until

W. H. HARRISON



BANCROFT GHERARDI

JOSEPH WEIL

1934, and has since been acting as secretary-treasurer. For many years he was counsellor of the University of Florida Branch. Dean Weil is a member of the current committee on instruments and measurements, and previously has served on the committees on sections, student branches, and education. He is secretary-treasurer of the Florida State Board of Engineering Examiners; a director of the Florida Engineering Society; and a member of the Institute of Radio Engineers, Society for the Promotion of Engineering Education, and various other societies.

Bachrach

E. C. STONE

CROSBY FIELD

Electrical World

J. F. BAILEY

E. C. Stone (M'19, F'31) recently was appointed vice-president and general manager of the Duquesne Light Company, Pittsburgh, Pa. Mr. Stone, who formerly was assistant to the president of the Philadelphia Company, Pittsburgh, was born March 8, 1882, at Charlestown, N. H., and was graduated from Harvard University with the degrees of bachelor of arts (1904) and bachelor of science (1905). He entered the service of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pa., in 1905, as an engineering apprentice. A year later he was appointed designing engineer in the transformer division of the engineering department. In 1911 he became associated with the Allegheny County Light Company, which two years later became the Duquesne Light Company, and remained with that organization for 20 years. In 1913 Mr. Stone organized the system operating department of the Duquesne Light Company and was system operator until 1919. In that year he was appointed assistant to the general manager, and in 1922 was made planning engineer. He was appointed manager of the systems development department in 1927 and held that position until 1931, when he was appointed assistant to the president of the Philadelphia Company. From 1925 until 1928 Mr. Stone was a member of the faculty of the school of business administration of the University of Pittsburgh, and conducted a series of courses on the economics of public utilities. In 1927 he served as a graduate lecturer at Yale University. He has contributed much to engineering literature, and presented papers to the World Engineering Congress at Tokyo, Japan, in 1929 and to the World Power Conference in 1930. Mr. Stone was a director of the Institute from 1925 until 1929 and was vice-president from 1929 until 1931.

Crosby Field (A'14, F'22) has been elected president of the American Society of Refrigerating Engineers. Mr. Field was born March 12, 1889, at Brooklyn, N. Y., and received the degrees of bachelor of science (1909) and mechanical engineer (1912) at New York University and Cornell University, respectively. In 1914 he received the degree of master of science in electrical engineering at Union College. Following his graduation from Cornell he was employed by the General Electric Company, Schenectady, N. Y. After a year during which he was engaged in private consulting engineering practice Mr. Field became chief engineer for Standard Aniline Products, Inc., in 1915. He became engineering manager of the National Aniline and Chemical Company in 1919, and since 1923 he has been vice-president of the Brillo Manufacturing Company, president and director of the Flakice Corporation, and president and director of the Chemical Machinery Corporation and the Chemical Machinery Construction Co., Inc. During the World War Mr. Field was a major in the Ordnance Department of the United States Army, and now holds a commission as colonel in the Ordnance Reserve Corps. He has written many articles for technical periodicals and has presented several papers before various engineering societies. He is a member of the American Association for the Advancement of Science, The American Society of Mechanical Engineers, American Institute of Chemical Engineers, American Chemical Society, Phi Beta Kappa, and several other professional and social organizations.

J. F. Bailey (A'29, M'35) who recently was elected vice-president and general manager of the Georgia Power and Light Company, Valdosta, formerly was manager of the northern division of the Florida Power Corporation at Ocala. Mr. Bailey was born May 6, 1890, at West Superior, Wis., and attended Carleton College. He entered the public utility business in 1914 as a service man for the Northern State Power Company at Northfield and Pine Island, Minn., where he remained until 1919. In the latter year he became construction superintendent for the Southern Minnesota Gas and Electric Company, and two years later was appointed superintendent of transmission, distribution, and operation. In 1926 he became chief engineer for the Central West Public Service Company, Omaha, Nebr. Following a brief affiliation with the Public Utilities Consolidated Corporation, Wallace, Idaho, as division manager, he became division manager of the Florida Power Corporation in 1930. Mr. Bailey was chairman of the AIEE Florida Section during 1935–36.

D. F. Miner (M'34) recently was appointed George Westinghouse professor of engineering at Carnegie Institute of Technology, Pittsburgh, Pa. Professor Miner, who will assume his new duties September 1, will act as co-ordinator for the Westinghouse Electric and Manufacturing Company's co-operative engineering plan under which a group of engineering students at Carnegie Institute of Technology will take the usual technical college course, and during the same period will receive shop and engineering experience at the Westinghouse plant. Professor Miner was born September 13, 1892, at Hazardville, Conn., and was graduated from Clark College in 1912 with the degree of bachelor of arts. He then enrolled at Worcester Polytechnic Institute, where he received the degrees of bachelor of science (1915) and electrical engineer (1917). Following his graduation he joined the Westinghouse company as assistant to the head of the electrical section of the research department. In 1927 he was made manager of the material and process engineering department, and in 1936 was promoted to the position of manager of the central engineering laboratories and standards. Professor Miner is a member of Tau Beta Pi and Sigma Xi.

R. L. Thomas (A'19, M'26) has become executive engineer of the Consolidated Gas, Electric Light, and Power Company of Baltimore, Baltimore, Md. Mr. Thomas formerly was general superintendent of the Pennsylvania Water and Power Company, Baltimore, an organization with which he was affiliated almost continuously since 1915. He was born at Marion, Ohio, in 1887 and was graduated from Princeton University (1909) and Massachusetts Institute of Technology (1913). Mr. Thomas has written many technical articles and has presented several papers before the Institute. During 1936–37 he was chairman of the AIEE Baltimore Section.

H. V. Carpenter (A'03, F'18) recently was awarded the honorary degree of doctor of laws by the State College of Washington, Pullman. He has been dean of the college of mechanic arts and engineering at that institution since 1915. Dean Carpenter was a vice-president of the Institute from 1930 until 1932, is at present a member of the committee on education, and was chairman of that committee during 1936–37.

F. I. Lawson (A'34) has been appointed engineer in the Bureau of Engineering of the Chicago (Ill.) regional office of the Federal Power Commission. Previously Mr. Lawson was engaged in the engineering department of the Pacific Gas and Electric Company, San Francisco, Calif.

W. D. Oliphant (A'37) recently received an appointment in medical electrology at the London (England) Hospital Medical College. Mr. Oliphant, a native (1907) of Edinburgh, Scotland, and a graduate of Edinburgh University (1928) formerly was senior technical assistant for the British Electrical and Allied Industries Research Association.

R. E. Claridge (A'30), formerly in the test department of Stromberg-Carlson Telephone Manufacturing Company, now is installing carrier-current systems and broadcast network equipment for C. P. R. Communications, with headquarters at Montreal, Que., Canada.

S. S. Huyett (A'34) has become the agent for New Goldfields of Venezuela, Ltd., Ciudad Bolivar, Venezuela. Mr. Huyett previously was a shift boss for Cameron Gold Mines, Inc., Cripple Creek, Colo.

C. J. Wells (M'37) has been appointed western regional electrical engineer for the United States Irrigation Service, with headquarters at Santa Fe, N. M. Mr. Wells formerly was chief electrical engineer for the irrigation service at Coolidge, Ariz.

L. M. Nelson (M'34) recently became superintendent of the electrical light department of the City of Rochester, Minn. Mr. Nelson formerly was superintendent of the water and light department of the City of Hastings, Nebr.

A. D. Bragg (A'36) recently was elected vice-president of the Engineers' Club of Fresno, Calif. Mr. Bragg is sales representative for the General Electric Company, San Francisco, Calif.

L. S. C. White (A'25) recently was elected president of the Gresham (Ore.) Chamber of Commerce. Mr. White is district manager of the Portland General Electric Company offices at Gresham.

Obituary

Carl George Schluederberg (A'02, M'13) vice-president and general manager of the Ford Instrument Company, Long Island City, N. Y., died at Cleveland, Ohio, April 9, 1938. Doctor Schluederberg was born June 11, 1880, at Pittsburgh, Pa., and was graduated from Cornell University with the degree of mechanical engineer in electrical engineering in the class of 1902. He then enrolled in the graduate school of that institution, following a training course with the Westinghouse Electric and Manufacturing Company at East Pittsburgh, and received the degree of doctor of philosophy in 1908. After a year in Europe he became electrical and mechanical engineer for the United Coal Company, Pittsburgh, but remained there for only one year before becoming a commercial engineer for the Westinghouse Electric and Manufacturing Company in 1910. He remained with that company for almost 25 years, serving in various departments at the East Pittsburgh works and later as general manager of the company's plants at South Bend, Ind. and Cleveland, Ohio. Doctor Schluederberg was the author of many papers and articles on chemistry and electrochemistry. He was enrolled in the Institute as a member for life and was a member of the American Chemical Society, American Electrochemical Society, and Sigma Xi.

Erwin R. Stoekle (M'17, F'33) vice-president of Globe-Union, Inc., Milwaukee, Wis., died March 14, 1938. Doctor Stoekle was born June 8, 1890 at Chicago, Ill., and received the degree of bachelor of science from Northwestern University in 1911. He then enrolled as a graduate student at the University of Wisconsin and received there the degrees of master of science (1913) and doctor of philosophy (1915). Following his graduation in 1915 he became a member of the laboratory staff of the Western Electric Company, New York, N. Y., where he became engaged in research on vacuum tubes and obtained a fundamental patent on high-power metal tubes for radio transmission. Two years later he went to Milwaukee to take charge of the physical laboratory of the Cutler-Hammer Manufacturing Company. In 1922 Doctor Stoekle established the Central Radio Laboratories in Milwaukee, and three years later, when his company was merged with the Globe-Union Manufacturing Company (later Globe-Union, Inc.), he became vice-president of the new organization. He was a member of the American Physical Society, Institute of Radio Engineers, American Association for the Advancement of Science, and Phi Beta Kappa.

Joseph Goodman (A'30) chief transformer engineer, General Electric Company, Ltd., Birmingham, England, died February 22, 1938. Mr. Goodman was born June 10, 1882, at Caterby, Northamptonshire, England, and was graduated from the Electrical Standardizing, Testing, and Training Institution ("Faraday House") in 1903. Following his graduation he was employed in the testing department of The British Electric Transformer Company, Ltd., Hayes, where he remained for two years. After one year as a tester for the Marconi Wireless Telegraph Company, Ltd., he returned to The British Electric Transformer Company as chief assistant in the designing and estimating department. He remained with that company for more than 20 years, becoming chief designer in 1928. Mr. Goodman transferred his affiliation to the General Electric Company in 1929, and was made chief transformer engineer. He was a member of the Institution of Mechanical Engineers and the Institution of Electrical Engineers.

Edward Winfield Judy (A'26) vice-president and general manager of the Duquesne Light Company, Pittsburgh, Pa., died March 24, 1938. Mr. Judy was born September 4, 1881 near Columbus, Ohio, and received his formal technical education at Ohio University. After a year devoted to construction work with the Scioto Valley Traction Company at Columbus he entered the employ of the Central Colorado Power Company. With that company, and later with Stone and Webster Engineering Corporation, he assisted in the construction of several of the large power projects in the western part of the United States. Later he became district manager of the Southern Sierras Power Company, Riverside, Calif. Mr. Judy joined the Duquesne Light Company in 1923 as superintendent of overhead lines, and was promoted to general superintendent of distribution in 1924. Early in 1927 he was appointed operating manager of the company and two years later was elected vice-president and general manager. Mr. Judy was a director of the Philadelphia Company, Duquesne Light Company, and the Equitable Sales Company. He was a past-president of the Pennsylvania Electric Association.

George Ernst Hayler (A'06, F'31) for more than 20 years an engineer in the public utility division of Cities Service Company, New York, N. Y., died March 18, 1938, of injuries suffered when he was struck by an automobile. Born December 18, 1871, at Ann Arbor, Mich., Mr. Hayler received the degree of bachelor of science in mechanical engineering at the University of Michigan in 1894. After serving for four years as superintendent of the Electric Light and Power Company, Van Wert, Ohio, he became manager of the Gas, Electric Light, and Power Company there in 1899. Later he became an engineer for the Arnold Company, Chicago, Ill., general manager of the Spring River Park Company, Joplin, Mo., and general manager of the Empire District Electric Company, Joplin. In 1915 Mr. Hayler went to New York to become an engineer for Henry L. Doherty and Company, and later for the Cities Service Company.

Russell Schutz Gueffroy (A'37) engineer with the Northwestern Electric Company at Vancouver, Wash., became separated from his party while on an attempt to climb Mt. Hood, March 27, 1938. He was not missed until the following day, when an extended search was organized and resulted in the recovery of his frozen body at the place where he had sat down to rest and had gone to sleep. Mr. Gueffroy was born August 2, 1909, at Salem, Ore., and obtained his technical education at the Oregon Institute of Technology in Portland, where he graduated in 1931. Following graduation he spent some time as assistant to the electrical engineer of the Oregon Pulp and Paper Company, Salem, before becoming associated with the Northwestern Electric Company. In addition to his work with the electric company he was teaching evening classes at Oregon Institute of Technology.

Albert John Joseph Murphy (A'19) manager of the New York Telephone Company, New York, N. Y., died February 18, 1938. Mr. Murphy was born in New York, October 28, 1895, and received his formal technical education at Pratt Institute and

Cooper Union. Mr. Murphy's entire technical career was spent in the employ of the New York Telephone Company. He became affiliated with that organization in 1916, and after gaining experience in several departments was appointed manager in 1928.

Membership

Recommended for Transfer

The board of examiners, at its meeting on April 19, 1938, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Board, V. L., vice-president and general superintendent, Public Service Company of Colorado, Denver.
Brainard, F. K., electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Crippen, R. P., consulting electrical engineer, Ebasco Services, Inc., New York, N. Y.
Gillespie, F. M., Seattle, Wash.
Inch, S. R., president, Electric Bond and Share Company and Ebasco Services, Inc., New York, N. Y.
Knapp, P. R., superintendent, electrical distribution and transmission, The Toledo Edison Company, Toledo, Ohio.
6 to Grade of Fellow

To Grade of Member

Bates, L. W., principal engineer and project manager, Bureau of Yards and Docks, Navy Department, Washington, D. C.
Harnett, D. E., engineer, Hazeltine Service Corporation, New York, N. Y.
Hitchcock, L. W., professor of electrical engineering, University of New Hampshire, Durham.
Hunt, O. H., engineer, The Bristol Company, Waterbury, Conn.
Hutchinson, C., electrical engineer, Tennessee Public Service Company, Knoxville.
Locke, W. W., instructor in electrical engineering and superintendent of dormitory, Worcester Polytechnic Institute, Worcester, Mass.
Lubcke, C. M., associate engineer, City Light Department, Seattle, Wash.
Neher, J. H., senior engineer, Philadelphia Electric Company, Philadelphia, Pa.
O'Kelly, F. C., sales engineer, General Electric Company, Denver, Colo.
Powell, R. W., electrical engineer, Central New York Power Corporation, Potsdam, N. Y.
Robb, W. F., traffic engineer, Southern New England Telephone Company, New Haven, Conn.
Roesch, R. E., division engineer, Virginia Public Service Company, Alexandria.
Sammis, W. H., vice-president, The Commonwealth and Southern Corporation, New York, N. Y.
Von Voigtlander, F., member, engineering staff, The Commonwealth and Southern Corporation, Jackson, Mich.
14 to Grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before April 30, 1938, or June 30, 1938, if the applicant resides outside of the United States or Canada.

United States and Canada

Ahlswede, N. E., 305 North Frances Street, Madison, Wis.
Allcorn, L. H., Jr., Hazelett Metals, Inc., Greenwich, Conn.
Anderson, W. E., Westinghouse Electric and Manufacturing Company, Bloomfield, N. J.
Bakker, W., Public Service Electric and Gas Company Newark, N. J.
Beaudway, R. W., General Electric Company, Philadelphia, Pa.
Beers, G. S., International Business Machines Corporation, Portland, Ore.
Benesh, F. A., Southwestern Light and Power Company Lawton, Okla.
Biele, C. E., Rockbestos Products Corporation, New York, N. Y.
Brown, A. M., Gibbs and Cox, Inc., New York, N. Y.
Cable, J. W., Consolidated Edison Company of New York, Inc., New York, N. Y.
Caskey, A. D., Public Service Company of Northern, Illinois, Chicago, Ill.
Catherwood, T. E. D., Buffalo Ankerite Gold Mines, Ltd., South Porcupine, Ont., Canada.
Clay, J. A., Utah Power and Light Company, Salt Lake City, Utah.
Craig, J. C., Puget Sound Power and Light Company, Seattle, Wash.
Currie, J. D., Tennessee Valley Authority, Wilson Dam, Ala.
Delius, H. A. (Member) California and Hawaiian Sugar Refining Corporation, Ltd., Crockett, Calif.
de Westfelt, G. P., (Member) New York Quotation Company, New York, N. Y.
Eacmen, J. C., 55 Limerick Street, Gardner, Mass.
Edwards, W. F., Public Service Electric and Gas Company of New Jersey, Camden.
Foster, W. S., University of Tulsa, Tulsa, Okla.
Freeman, O. M., (Member) Consolidated Edison Company of New York, Inc., New York, N. Y.
Frehner, P. H., Pacific Electric Manufacturing Corporation, San Francisco, Calif.
Fuller, R. C., Tennessee Valley Authority, Wilson Dam, Ala.
Garceau, L., (Member) Electro-Medical Laboratory, Inc., Holliston, Mass.
Guernsey, E. D., Bell Telephone Laboratories, Inc., New York, N. Y.
Hediger, F. (Member) 70 Remsen St., Brooklyn, N. Y.
Howe, E. L., Simplex Wire and Cable Company, Philadelphia, Pa.
Humphery, S. M. (Member) Taylor-Winfield Corporation, Warren, Ohio.
Jacobs, O. R., Ohio Power Company, Lima.
Janssen, H. F., Allis-Chalmers Manufacturing Company, Philadelphia, Pa.
Jorow, E., Square D Company, Los Angles, Calif.
Kaye, R. S., Westinghouse Electric and Manufacturing Company, Boston, Mass.
Kleene, W. F., (Member) Commonwealth Edison, Company, Chicago, Ill.
Knowles, P., Utilities Service Company, Allentown, Pa., Charlotte, N. C.
Leigh, J. S., RCA Manufacturing Company, Camden, N. J.
L'Hommedieu, W. P. (Member) Westinghouse Electric and Manufacturing Company, San Francisco, Calif.
Locke, W. C., 100 Gainsboro Street, Boston, Mass.
Lomasney, B. J., Reda Pump Company, Bartlesville, Okla.
McCleskey, S. L., Jr., Orangeburg Water and Light Plant, Orangeburg, S. C.
McLelland, C. C., Memphis Light and Water Division, Memphis, Tenn.
McOmber, M. W., Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn.
Miller, F. E., San Joaquin Light and Power Company, Santa Maria, Calif.
Miller, G. H., Consolidated Edison Company of New York, Inc., Brooklyn, N. Y.
Minzner, W. R., 42 Baremeadow Street, Methuen, Mass.
Moes, G., (Member) Hamilton Sterling Electrical Company, Ltd., Hamilton, Ont., Canada.
Muniz, R. (Member) Brooklyn Technical High School, Brooklyn, N. Y.
Neely, T. H., Bell Telephone Laboratories, In New York, N. Y.
Painter, J. H., New Jersey Bell Telephone Company, Newark.
Potts, H. M., Public Utility Districts, Tacoma, Wash.
Pratt, L. W., Hydro-Electric Power Commission of Ontario, Toronto.
Raynes, R. K. (Member) 98 Church Avenue, Fairville, N. B., Canada.
Renner, H. H., 2210 University Avenue, New York, N Y.
Richmond, L W., Chesterland, Ohio.
Schlesinger, J. P. Jr., Bethlehem Steel Company, Sparrows Point, Md.
Schonefeld, M. F., Indiana Service Corporation, Ft. Wayne, Ind.
Searight, F. H., Allis-Chalmers Manufacturing Company, Milwaukee, Wis., San Francisco, Calif.
Simpson, W. A., Timken Roller Bearing Company, Canton, Ohio.
Skyllingstad, D. E., United Light and Power Engineering and Construction Company, Kansas City, Mo.
Smith, M. J., Houston Lighting and Power Company, Houston, Texas.
Smith, R. A., Delavan Engineering Company, Des Moines, Iowa.
Smith, V. A., Reda Pump Company, Bartlesville, Okla.
Starkweather, H. C., (Member) United States Army, Baltimore, Md.
Stratton, M. E., Carnegie-Illinois Steel Company, Ind.
Stroud, E. A., Southwestern Light and Power Company, Lawton, Okla.
Styner, P. M., (Member) The Empire District Electric Company, Joplin, Mo.
Sumner, M. R., (Member) Federal Power Commission, Washington, D. C.
Tuttle, D. F., Jr., Bell Telephone Laboratories, Inc., New York, N. Y.
Weil, A. F., Southern Indiana Gas and Electric Company, Evansville, Ind.
White, A., Spencer Thermostat Company, Attleboro, Mass.
Wortman, H. B., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Wright, R. F., General Electric Company, New Orleans, La.
Total, United States and Canada—71

Elsewhere

Bennett, R. S., (Member) Thomas Firth and John Brown, Ltd., Sheffield, England.
Ely, E. S., Southern Railway England, Southampton, England.
Krishnaswami, A. C. K., in care of Messrs. Seshasayee Bros., Ltd., Tennur, Trichinopoly, South India.
Kwatra, J. N., Siemens (India), Ltd., Lahore, India.
Lewis, H. A., British Broadcasting Corporation, Surrey, England.
Ryan, E. R., University College, Galway, Ireland.
Sundararaman, R., Crompton Engineering Company (Madras), Ltd., Madras, South India.
Tao, S., Tokyo Electric Company, Ltd., Kawasaki, Japan.
Yleana, G. E., (Fellow) Ma-ao Sugar Central Company, Inc., Occidental Negros, P. I.
Total elsewhere—9

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Society Library, New York, recently are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface of the book in question.

COMMISSION INTERNATIONALE de l'ÉGLAIRAGE, 9th Session, Berlin and Karlsruhe, July 1935. RECUEIL, des TRAVAUX et COMPTE RENDU des SÉANCES. Published under the direction of the National Physical Laboratory of Teddington, England. Cambridge, England, University Press, 1937. 679 pages, illustrated, 10 by 6 inches, cloth 20s. Contains reports of the proceedings of the ninth meeting of the International Lighting Commission, its official recommendations and also the reports presented by various technical committees. Discusses trends and developments in many directions: photometry; the lighting of streets, factories, and mines; aviation and automobile lighting; traffic signals; and artificial daylight. The reports are in English, French, or German, with brief summaries in all three languages.

TECHNICAL MATHEMATICS, 3 volumes. By H. M. Keal and C. J. Leonard. Second edition. New York and London, John Wiley & Sons, 1938. Volume 1, 246 pages; volume 2, 277 pages; volume 3, 314 pages, illustrations, 7 by 5 inches, cloth, $1.25 each volume. The three volumes of this secondary or trade-school textbook treat respectively the subjects of algebra, geometry, and trignometry.

NATIONAL ELECTRICAL CODE HANDBOOK. By A. L. Abbott. 4 edition. New York and London, McGraw-Hill Book Company, 1937. 561 pages, illustrations, 8 by 5 inches, leather, $3.00. Discusses the provisions and practical application of the National Electrical Code.

DEUTSCHES MUSEUM Abhandlungen und Berichte, Jg. 9, Heft 5. Die ENTWICKLUNG der TELEGRAPHIE auf DRAHTLEITUNGEN, by E. Feyerabend. Berlin, VDI-Verlag, 1937. 145 pages, illustrated, 8 by 6 inches, paper, 0.90 rm. A brief account of the evolution of telegraphy in Germany.

(The) ADMINISTRATION of FEDERAL GRANTS to STATES. By V. O. Key, Jr. Published for the Committee on Public Administration of the Social Science Research Council by Public Administration Service, Chicago, 1937. 388 pages, tables, 9 by 6 inches, cloth, $3.75. One of a series of studies of the administrative problems of the social security program. Limited to an examination of administrative practices, policies, and problems from several federal agencies and jointly financed state activities.